SUPPORT SERVICES TO THE NATIONAL RENEWABLE ENERGY LABORATORY

FINAL REPORT
[Draft]

Subcontract No. YAC-4-14043-01

December 19, 1994

Prepared for:

National Renewable Energy Laboratory
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1.0 Introduction

This is the Final Report on the services provided by Technology & Management Services, Inc. to the National Renewable Energy Laboratory (NREL) under Subcontract #YAC-4-14043-01 related to planning, program and issue analysis assistance for the U.S. Department of Energy (DOE) Biofuels Program. As the field manager for the U.S. DOE Office of Transportation Technologies, Biofuels Program, NREL supports major planning, programming and budget analysis initiatives to ensure consistency of program objectives with the Energy Policy Act. Prior to issuance of the subject contract, NREL recognized a need for an increased level of specialized expertise in order to enhance responsiveness to Biofuels Programs needs. TMS' support activities were conducted pursuant to the requirements of Tasks 1 and 2 under the subcontract. A Statement of Work for Tasks 1 and 2 is included in Appendix A.

The work on Tasks 1 and 2 began December 20, 1993, and was completed on December 19, 1994. Deliverables were provided as described in the Statement of Work. The type of assistance provided for planning, program, and issue analysis required TMS to undertake a number of different activities including:

- Review and assessment of the Biofuels Program documents describing current and planned program activities.
- Review and assessment of strategic planing documents prepared by the Biofuels System Division, Office of Transportation Technology, and Department of Energy.
- Review of Energy Policy Act of 1992 and assessment of implications for renewable transportation fuels development and utilization.
- Review of literature on technical, economic, and policy biofuels issues and related topics and compilation of citations into a subject matter bibliography.
- Review activities of international organizations (e.g., United Nations, World Energy Council, International Energy Agency) in the area of biofuels R&D and technology transfer.

- Identify existing analytic tools that could be applicable to Strategic and Program Planning, and Programming, and identify means for their enhancement and/or validation.

The results of these activities are reflected in deliverables and other analytic documents provided. The remainder of this report provides detailed discussions of each of the deliverables and responses to additional requests.

2.0 Preliminary Assessment of Critical Planning Factors

The document, *Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program*, was submitted as May 31, 1994 in compliance with the first deliverable as specified in the SOW. This document was developed to provide information useful for strategic decision-making. It adapted the specialized viewpoint of a corporate Product Manager as a means for identifying and assessing critical success factors for the ultimate achievement of BSD program objectives.

TMS undertook a detailed investigation of Biofuels Program Plans, other relevant DOE strategic plans, and the Energy Policy Act objectives. Comparison of this information provided the basis for assessing the completeness and correlation of the Biofuels Program Plan to Energy Policy Act objectives. The SOW refers to the National Energy Strategy (NES) that was the policy-guiding document. With the passage of the Energy Policy Act, the client asked to use the provisions and objectives in this document instead of the outdated NES. To organize and assess the necessary information, TMS investigated ten different aspects of Biofuels Program Plans:

- Program Design
- Investment Scenario
- Control of Policy Analysis
- Constituency Building Analysis
- Timing
- Compliance
- R&D Feedstock
- R&D Conversion
- Program Diversity and Priority
- Land Use

Each of these aspects of Biofuels Program Plan was assessed from the perspective of an effective Product Manager. For a Product Manager to be effective, there must be a product offered on the market that is, (1) clearly and simply identified; (2) differentiated from other products by unique benefits; (3) appropriately priced, taking its benefits into account; and (4) reliably available, with an appropriate infrastructure for delivery and service. TMS based its review on an extensive literature search and personal interviews with staff at BSD and NREL. The type of information sought in these interviews is reflected in Exhibit 1. Findings were developed and organized into this deliverable. A copy of the report is found in Appendix B.

Exhibit 1
Illustrative Topics for Discussion at NREL
TMS Visit
April 27-28, 1994

1. Models used by NREL to evaluate/analyze
   - penetration and commercialization of biofuels technology
   - comparative attractiveness, benefits, cost of alternative transportation technologies and fuels
   - nature of emissions and their impacts (e.g., greenhouse gas effects) of alcohol fuels
   - land availability and use issues of biofuels, both in U.S. and globally

   Also discuss NREL interactions with models for similar purposes being developed and/or used by others

2. R&D program for biofuels conversion with emphasis on cost reduction over time scenario. What potential exists for trading off time, cost, risk, etc.

3. NREL procedures for CRADAs. What potential areas are of interest with respect to the generation of additional CRADAs? What are the barriers to accomplishing them?

4. Production of ethanol from MSW. Is this an opportunity for niche market entry?

5. Brazil. Is experience in Brazil fully available? Are there reasons (benefits) to be associated with more extensive interaction, data exchange, etc.?

6. Intersections between programs using biofuels for transportation and biofuels for electricity.

7. State involvement in supporting biofuels objectives, including support of flexible fuel vehicles for fleet use.

8. NREL views of biofuels strategic planning activity and status.

3.0 Cost-Sharing Options

The document, *A Biofuels Transportation Program Cost-Sharing Strategy: Building Success Today for Tomorrow's Expanding Biofuels Market*, was submitted on July 29, 1994 in compliance with the second deliverable specified in the SOW. This document develops a structure for an enhanced cost-sharing strategy for the Biofuels Transportation Program. A central feature of this strategy is the use of cost-sharing as a means to an end rather than as an end unto itself. Effective cost-sharing activities are targeted to accomplish specific program goals. The cost-sharing strategy recommended here goes beyond the practice of leveraging federal research dollars with other research funders. It is designed to expand the active program constituency, and enhance the focus of the program on near-term progress towards its vision of bioenergy as an essential component of an environmentally sound and transportation system.

This report describes a cost-sharing strategy that builds on related program activities already in progress, and which can be expanded in scope today. It follows the Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program, submitted May 31, 1994, which discussed the biofuels transportation product line, four critical success factors, and the usefulness of the overall perspective of a corporate Product manager. Cost-sharing is a vital tool of any Product Manager's product development plan, and is one which, in this case, directly supports the key success factors which have been previously identified.

The first section of this report established the basis for the proposed cost-sharing structure and strategy by reviewing the competitive market factors which place a premium on near-term activity and constituency building. The second section discusses the broadened characterization of cost-sharing which is adopted in this report to develop the strategy, and how that strategy is derived from the intersection of program needs and stakeholder's motivations. The final section presents the resultant strategy elements and specific illustrative actions within its various categories which can be considered for early implementation. A copy of the report is provided in Appendix C.

4.0 Technical, Economic, and Market Risk Mitigation

The document, *Risk Management Pathways for the Biofuels Transportation Program*, was submitted October 31, 1994 in compliance with the third deliverable as specified in the SOW. This document proposed specific risk management pathways for the Biofuels Transportation Program, based on an independent assessment of important technical, economic, and market risks inherent in the conduct of the program.

The material presented here incorporates and builds upon insights developed in the two previous deliverables.

In both of these prior studies, the importance of strategic program planning based on the concepts of a corporate Product Manager was emphasized. In this view of the world, program success is associated with the anticipated deployment of technology and systems in commercial market places, delivering actual benefits to investors, suppliers, and users. Critical program strategies are those which tend to increase the probability of the desired outcome. Risks are those factors which increase the difficulty of achieving success. Risk management pathways are specific critical program strategies intended to mitigate risks, and thereby enhance the likelihood of ultimate benefit delivery.

The current BSD program structure is quite complex in that it comprises (or must take into account) related elements across the entire fuel cycle which extends from biofuel production, harvesting, storage, distribution, pre-treatment, and conversion; to liquid transportation fuel product blending, distribution, and end-use device utilization; along with related issues of waste management, land use, and other environmental, health and safety impacts.

Our focus here is on closed loop (renewable) biomass. There are both annual and multi-year energy crop resources. Conversion techniques may involve anaerobic digestion or themorechemical approaches. Products may comprise neat ethanol or additives in the form of ethanol (or gasohol) or oxygenated ethers (for reformulated gasoline). A further product involves

biodiesel fuels made from still other renewable sources.

Building on findings regarding risk and product commercialization, the report assesses risk issues from five different perspectives:

- The Dilemma of Expectations and Promises
- Schedules and Cost Estimates
- Connecting Development to Deployment
- Completeness
- Educating Stakeholders About Environmental Externalities

For each perspective, the barriers to program success posed by risk and programmatic responses that anticipate issue of risks, and enhance the likelihood of overall program success are discussed. A copy of the report is provided in Appendix D.

5.0 Topical Area Reports

As specified in the description of the fourth deliverable, TMS submitted stand alone documents on international activities including biofuels and technical, economic and market assessments of how the Biofuels Program could benefit from continued participation in these international activities.

TMS provided three stand alone documents addressing issues of U.S. participation in the International Energy Agency (IEA) Bioenergy Agreements:

1. Observations on the IEA Bioenergy Agreement
2. Review of Draft Strategy Plan: IEA Bioenergy Agreement
3. IEA Bioenergy Agreement: Strategic Plan - August 1994

A copy of these documents is provided in Appendix E.

To prepare these documents, TMS drew on the extensive knowledge of the operations of the IEA and the role Implementing Agreements play in the exercise of IEA priorities and activities. In addition, TMS collected information from the IEA Working Party on Renewable Technology on their current and planned activities, reviewed the provisions of the current IEA Biofuels Implementing Agreement, and assessed the potential benefits to the U.S. by continued participation in the Agreement.

6.0 Analytic Tools

In addition to the deliverables discussed above, the SOW called for identifying analytic tools that could be applicable to strategic and program planning, and programming and identifying means for their enhancement and/or validation. This work has been performed as a necessary prerequisite for meeting the requirements of the third contract deliverable, assessment of the technical, economic, and market risks for competing biofuels technology.

Given the importance of risk identification and mitigation strategies, TMS believes that analytic tools of particular value to the Strategic Planning process are those which facilitate the analyses of market penetration and the characterization of uncertainty. Because Strategic and Program Planning, and Programming activities address broad issues of structure, they are quite amenable to the use of personal-computer (PC), spreadsheet-based models. The rapid increases in PC computing power and speed now make it possible for users to interact in real time with sophisticated and complex models so as to gain unique insights into strategic and programmatic issues.

TMS has substantial experience with the design, construction and generation of PC-based models for strategic analyses. In order to maximize their utility, such models should:

- Use commercially available software;
- Embody an appropriate level of mathematical and statistical complexity in their design;

- Be directly connected to the decision-making (program design and execution) process;
- Operate in an interactive mode with the user, including an integrated capability for scenario experimentation and sensitivity analysis;
- Emphasize multiple views of the world;
- Include explicit treatment of both risk and uncertainty in inputs and outputs; and
- Provide for ready extension and/or modification as the issues to be explored may change over time.

We have reviewed the available systems and summarize here those techniques (and programs) that appear to have high potential utility for the Biofuels Transportation Program.

With respect to the underlying spreadsheet environments, the Windows-compatible versions of Excel^{R}, QuattroPro^{R}, and Lotus 1-2-3^{R} all offer similar capabilities. Most of the analytic add-ons or work-along-sides discussed below are created for Lotus 1-2-3^{R} (and occasionally Excel^{R}), whereas QuattroPro^{R} has superior built-in functions. All three spreadsheets now include an excellent capability to generate user-friendly, front-end dialogue boxes and speed (button) bars which will facilitate their use by decisionmakers with only minimal computer experience.

For market penetration studies, Gompertz growth curves and related mathematical functions may readily be constructed on spreadsheets using three variables: introduction date (for a given entry level magnitude), time to a specified percent of market saturation, and the asymptotic level of total market saturation. Multiple growth curves can be summed to simulate the effect of diffusion from niche market entry to a broader market target following cost reductions achieved through learning curve effects.

Another mathematical market modeling technique, well suited to strategic-level spreadsheets, is the use of Markov matrices. The market condition in a subsequent time period is a probabilistic function of the market condition in a prior time period. Market "states" can be few or many, depending on the degree of realism or detail designed. Each individual "run" (spreadsheet

recalculation) is a simulation. Spreadsheet macros can be written to develop probabilistic statistics of a range of outcomes.

A more sophisticated extension of this concept is the commercial software program @RISK[R]. This add-in for 1-2-3[R] or Excel[R] provides 34 probabilistic distributions which can be incorporated directly into spreadsheet equations. Either expected values or randomly sampled results can be returned. Detailed statistical characteristics are captured for data output cells. @RISK[R] can also be connected to Microsoft Project[R]. Related software includes RISKview[R] (for viewing, assessing and creating distributions) and Best Fit[R] for fitting distributions.

Forecasting tools that provide a good level of sophistication and simple techniques for data entry include Forecast Pro[R] and Fore Calc[R] (the latter being an add-in for 1-2-3[R]).

Optimization packages are particularly useful scenario analysis tools. For linear programming, What's Best[R] is the commercial package of choice. It can handle up to 32,000 variables, and is an add-in for Excel[R] as well as the DOS versions of 1-2-3[R] and QuattroPro[R]. The Windows-based spreadsheets incorporate internal optimization tools (including non-linear techniques) which are adequate for most smaller size problems. Again, spreadsheet macros can be created to generate and store consolidated information on multiple outputs, and front-end entry menus and dialog boxes can be created so that non-sophisticated users can operate the analysis system.

Decision trees and influence diagrams represent still another means to structure and analyze scenarios with significant probabilistic content. DPL[R] is the commercial program of choice. An important virtue of this system is its ability to be linked directly to a Windows-based spreadsheet.

Somewhat more complex (and less clearly adaptable to real problems that cannot be easily solved by other techniques) are an emerging set of artificial intelligence and neural network systems. Typical commercial systems include @Brain[R] (add-in for 1-2-3[R]) and Neuralyst[R] (add-in for Excel[R]). We do not currently recommend these for applications. However, a better appreciation of virtues may develop over time with continued experimentation and familiarity.

A final and extremely useful mathematical analysis technique is output ranking through the use of the Analytic Hierarchy Process (AHP). The commercial software of choice is Expert Choice^{R}. One of its major virtues is the ability to reverse-engineer results in order to obtain major insights as to the key factors affecting the outcomes. For this reason we view it more as an analysis tool that as a ranking generator.

Our experience is that the application of these techniques and tools, in association with small interactive spreadsheet models, can provide important strategic-level planning results (and associated sensitivity analysis and probabilistic range information) to any program area that uses them consistently and creatively. We recommend their adoption by the Biofuels Transportation Program.

7.0 Outreach

In addition to the deliverables previously described, the SOW requires TMS to conduct activities, consistent with the SOW, on a quick-response basis as requested. Most quick response requests involved the program need to address critical issues which extend beyond the necessary primary tasks of technology, cost, and performance, but which are essential to overall program success. As enumerated in the TMS proposal these are: to expand the capability to grow an external program constituency; to establish a strong international overlay to leverage investments and target benefits associated with U.S. exports and domestic job growth; and to focus on regulatory, financial and environmental context which can help reduce market risk or mitigate barriers to commercialization. These activities are treated in this section under the general heading of Outreach.

Our approach to these activities recognized the need for a thorough TMS understanding of the BSD program and its underlying legislative mandates as a prerequisite to operating as an effective agent for reinforcing and expanding the community of program stakeholders. At the same time we appreciated the requirement for early engagement with those organizations already active in the biofuels arena to establish working relationships to achieve short term program

priorities. Finally, our approach emphasized the necessity to segment the outreach activity into useful categories of endeavor to facilitate program guidance and prioritization of effort.

During the initial months of the contract the TMS team undertook an intensive research effort on issues related to the BSD program. This included review and analysis of legislative and regulatory mandates and Administration and Department initiatives affecting the Biofuels Program. Material reviewed included:

- Energy Policy Act (EPACT)
- The Climate Change Action Plan
- Environmental Protection Agency's Renewable Oxygenate Requirement for Reformulated Gasoline
- Clean Air Act Amendments of 1990
- CAFE Standards
- Alternative Motor Fuels Act (AMFA) of 1988
- DOE's Cost-competitive Ethanol Fuels Initiative
- Solar R&D Act of 1974

This review of legislative, regulatory and program materials, in addition to providing information critical to the development of the first contract deliverable, "Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program", contributed to our understanding of the interrelationship of the BSD program with other elements of government at all levels as well as with the private sector. It also supplemented our effort to review the stakeholder related program initiatives and to suggest an approach that segments the strategy for leveraging program resources through stakeholders into ten specific territories. As described in TMS's second deliverable, "A Biofuels Transportation Program Cost-Sharing Strategy", these territories consist of the following.

1. Policy Umbrella Initiatives defined as those initiatives relevant to the Biofuels Program that bring together a variety of interrelated topics (eg. DOE's Clean Cities program and the administration's Climate Change Action Plan)

2. International Organizations such as the International Energy Agency, the United Nations, and the World Energy Council

3. State and Local Governments, many of whom are already active in the promotion of biofuels at the state and local level

4. Other Federal Agencies and programs such as USDA, DOT, EPA, DOC and DOD (Advanced Research and Program Agency) who have to various degrees the mandates, funding and interest to support biofuels initiatives

5. Bilateral Agreements between the U.S. and other nations to cooperate on biofuels development

6. Large Companies with Diversification Potential including business investors and companies who believe they can make a profit in each of the components of the biofuels support system

7. Environmental Community including those groups that are ambivalent about the environmental merits of biofuels development

8. Regional Technical and Information Networks such as universities and organizations positioned to set up regional centers of excellence or to take advantage of innovations in communications technology to promote biofuels development

9. Biotransportation Association with a mission to provide timely, quick response information on biofuels and to provide member services to the biofuels community

10. Media which is well-positioned to provide information on future biofuels viability in the market place

These territories were outlined in an effort to structure our own thinking on stakeholder development activities as well as to facilitate future client prioritization of the TMS support effort in this area. While TMS recognized from the outset the need for a structured outreach activity, grounded in a good understanding of the program and the technologies being promoted, we also placed a premium on those activities necessary for near-term liaison with the most active elements of the stakeholder community. The following provides a representative sample of this activity.

TMS staff met with the leadership of the Solar Energy Industries Association in March and initiated subsequent direct meetings between that organization and DOE program personnel. Our staff also attended meetings of and ultimately joined the Biomass Energy Research Association. Through this and other forums, TMS staff were able to establish dialogue with the Biomass Energy Research Association (Mr. Donald Klass), the Renewable Fuels Association (Mr. Eric Vaughn), the Clean Fuels Development Coalition (Mr. Douglas Durante), and the Center for Renewable Energy and Sustainable Technology (CREST; Mr. Michael Totten).

Direct meetings between DOE program staff and CREST personnel were held to review that organization's efforts to utilize CD-ROM and Internet technology to create cost-effective educational materials promoting the use of renewable energy and, in particular, biofuels. As a result, biofuels program materials were supplied to CREST by DOE's Sarah Sprague for inclusion on CREST's CD-ROM products and in their Internet files. This activity effectively leverages BSD information resources into two existing DOE-EE contracts with CREST to support renewable energy education efforts. These are an EE-10 contract for an educational CD-ROM game targeted to high school age students and an EE-54 contract to support CREST work with Internet.

TMS staff also attended meetings of the EPPC Task Force on Sustainable Development at the American Association of Engineering Societies (AAES) headquarters in downtown Washington, D.C. These meetings were usually well attended by up to forty individuals from the private sector and by representatives of the White House, EPA and other federal agencies. Representative of the value of these meetings was one that occurred on August 30. At that gathering of the Task Force, Mr. David Rejeski, with the White House Office of Science and Technology, spoke on "Technology for a Sustainable Future" and specifically on developing a National Environmental Technology Strategy. In a followup discussion with TMS staff, Mr. Rejeski identified staff with the World Bank's Asian Technology Development, Environment and Natural Resource section, who had conveyed to him their impression that World Bank U.S. trust accounts to promote "clean" U.S. technologies abroad were being underutilized. TMS staff used this discussion as a point of entry to the Bank on behalf of the Biofuels Program.

TMS' support to the Biofuels Program benefited from its related work to other elements of DOE. For instance, TMS was engaged by DOE-FE and the Office of the Secretary to support the Secretary's trade mission to India on Sustainable Energy and Trade and to assist in the planning of a similar mission to China. In these capacities, TMS helped in the development of briefing materials and reviewed agreements reached on INDO/US government cooperation to monitor work in the energy sector and to expedite the implementation of projects. TMS continues to monitor opportunities for the Biofuels Program to become a more active participant in these international activities.

One of the more significant events during the calendar year involved EPA's proposed and ultimately final rule making on: "The Regulation of Fuels and Fuel Additives: Renewable Oxygenate Requirement for Reformulated Gasoline." TMS staff gathered materials and provided DOE program personnel with updates on the progress of the ruling. Congressional testimony was collected and summarized. We monitored closely press accounts on the impact of the ruling. We also supplied materials to DOE which could be used in response to stories that confused the current use of corn crops to produce ethanol at a subsidized cost with the BSD program goal to promote downstream competition in the marketplace through improvement in feedstocks and conversion processes.

Contact with other DOE National Laboratory personnel was occasionally undertaken as a response to specific requests for information on reports deemed relevant to the Biofuels Program. For instance, in May TMS staff contacted Ms. Margaret Singh of the Argonne National Laboratory to retrieve and analyze two studies related to the use of ethanol in reformulated gasoline. The resulting invitation for continued dialogue and technical peer review of analyses was typical of other interactions with National Laboratory personnel.

Quick turn-around assignments to profile regions and/or states prior to DOE meetings or trips were occasionally undertaken by TMS. Economic, agricultural and demographic summaries were provided through the use of information sources such as the USDA's National Agricultural Statistics Service.

At the request of OTT/BSD, TMS provided in October a summary of the Florida Energy Office's RFP entitled: "Local Government Alternative Fuel Vehicle Initiative" and evaluation summary formats for use by DOE personnel. The resulting product facilitated the review of 42 local government proposals.

The work statement for 1995 appropriately envisions a proactive and balanced effort to engage and service the needs of stakeholders who are currently direct participants with the program as well as those who are non-participants. The stakeholder outreach activities undertaken during the contract year provide the Biofuels Program and our own staff with a solid foundation for continued work in this area during the coming contract year.

8.0 Conclusion

With the submission of this Final Report, TMS has met all contractual requirements as specified in the SOW.

APPENDIX A

Statement of Work

APPENDIX A

STATEMENT OF WORK

Planning, Program and Issue Analysis Assistance for the Biofuels Program

September 17, 1993

Introduction

As the field manager for the U.S. Department of Energy's (DOE) Office of Transportation Technologies, Biofuels Program, NREL supports major planning, programming and budget analysis initiatives to ensure consistency of program objectives with the National Energy Strategy (NES). NREL now recognizes an increased level of specialized expertise in order to enhance responsiveness to Biofuels Program needs. Planning, program and issue analysis assistance is required in the following areas specified in the Scope of Work.

Scope of Work

The Subcontractor shall support NREL requirements to assist the Biofuels Program through the provision of technical support for planning, programming and issue analysis in response to DOE guidance.

Task 1 Planning and Programming

In the area of Planning and Programming, the Subcontractor shall conduct a review of assigned technical planning issues as follows:

a) Assist program management in developing a planning process for the Biofuels Program. Critical factors associated with one or more of the elements of probable technical success, product or systems development success, and the ability to achieve economic application and success through commercialization by the private sector will be identified and emphasized in the process.

b) Assist in developing a planning strategy and basis for the Biofuels Program relative to the possible trade-offs among scope, cost, time, and risk.

c) Identify options for increasing private sector cost sharing.

Task 2 Issue Analysis

In the area of Issue Analysis, the Subcontractor shall conduct a review of assigned technical cross-cutting issues as follows:

a) Evaluate technical, economic and market uncertainties, and identify means for their full or partial resolution.

b) Identify existing analytic tools that could be applicable to Strategic and Program Planning, and Programming, and identify means for their enhancement and/or validation.

The Subcontractor shall conduct the above activities on a quick-response basis, as required, and in close coordination with NREL and participating DOE Energy Efficiency and Renewable Energy (EE) program managers utilizing NREL capabilities. The Subcontractor shall accordingly participate in regularly-scheduled review meetings at both NREL and EE, in accordance with needs dictated by the requirements of the ongoing work.

Deliverables

Subcontractor shall submit the following reports by the due dates indicated.

	Deliverable	Due Date
1.	Preliminary assessment of the Biofuels Program Plan in terms of completeness and correlation to National Energy Strategy objectives.	Three months subsequent to subcontract initiation.
2.	Report on public/private cost sharing options and their applicability to the Biofuels Program.	Seven months subsequent to subcontract initiation.
3.	Assessment of the technical, economic, and market risks for the competing Biofuels Technologies.	Nine months subsequent to subcontract initiation.
4.	The Subcontractor shall submit formal Topic Area Reports, as NREL may designate from time to time, covering results obtained in major areas of work which are amenable to reporting on a stand-alone basis.	As required.
5.	The Subcontractor shall submit informal presentations of the results of work-in-progress as NREL may require from time to time.	As required.

Standard Reporting Requirements

In addition to the deliverables listed above, the Subcontractor shall prepare and submit the following reports to the NREL Technical Monitor, the Biofuels Program Subcontract Coordinator, and the NREL Subcontract Administrator. Distribution shall be as specified in the Addresses section below.

A. MONTHLY TECHNICAL STATUS REPORT: A monthly report to communicate to NREL an assessment of subcontract status, to explain variances and problems, and to discuss any other areas of concern or achievements. This report should be one or two

pages written in a letter format with emphasis placed on the status and a description of the progress. This report is due on or before fifteen days after the completion of each month. A monthly technical status report is not required if the Annual Technical Progress Report or the Final Technical Report is due at the completion of the month.

B. FINAL TECHNICAL REPORT: A formal, structured technical report prepared in accordance with the enclosed *Style Guide for NREL Subcontractor Reports*. This report shall describe all significant work performed during the entire subcontract. A draft Final Technical Report is due on or before sixty days prior to the completion date for this subcontract. The Subcontractor shall make corrections or revisions per NREL direction upon receipt of the revisions. The Final Technical Report is due on or before fifteen days after receipt of NREL's recommendations for revisions or approval. If the subcontract is modified for an additional year's effort, the Annual Technical Progress Report shall be due instead of this report.

C. ANNUAL TECHNICAL PROGRESS REPORT: If this subcontract is modified for an additional year's effort, the subcontractor shall prepare and submit in draft and final version an Annual Technical Progress Report covering the work performed during the first year of subcontract performance in the same manner as the Final Technical Report.

D. CONTRACT MANAGEMENT SUMMARY REPORT: The Subcontractor shall submit a Contract Management Summary Report (CMSR), DOE Form 536 or similar format that indicates the proposed cost plan, by-month and cumulative, for this subcontract. The original submittal (due upon contract award) shall serve as the cost plan for this subcontract, and monthly submittals shall indicate the actual costs incurred versus the planned costs. The Subcontractor shall indicate and explain any variances between planned and actual costs and whether these variances will impact the final estimated cost for performance of this subcontract effort. The CMSR report shall be submitted no later than the 15th day of each month in accordance with the Addresses section which follows.

E. COPIES OF ANY TECHNICAL PAPERS OR PRESENTATIONS: The subcontractor shall provide copies of all papers or presentation materials for activities relating to the work supported through this subcontract.

Addresses

One copy of all deliverables (two copies of the CMSR) shall be sent to the Subcontract Administrator:

National Renewable Energy Laboratory
Attn: Chuck Rasey
1617 Cole Blvd.
Golden, CO 80401

Two copies of all deliverables shall be sent to the Technical Monitor:

Mr. Carl Wallace
NREL Washington Office
409 12th St. SW - #710
Washington, DC 20024-2188

Two copies of all deliverables shall be sent to the Biofuels Program Subcontracts Coordinator:

National Renewable Energy Laboratory
Attn: Mark Yancey, 15/2
1617 Cole Blvd.
Golden, CO 80401

APPENDIX B

Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program

Preliminary Assessment Of Critical Success Factors For The Biofuels Transportation Program

DRAFT

Prepared for:
National Renewable Energy Laboratory
Subcontract No. YAC-4-14043-01

Prepared by:
Technology & Management Services
18757 North Frederick Road
Gaithersburg, MD 20879

May 31, 1994

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Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program

1.0 Strategic Planning and the Product Manager

The transportation sector is at the forefront of national concerns with respect to its critical impacts on petroleum consumption, environmental emissions, and U.S. industrial competitiveness. The forces for change are intense, and will clearly lead to a major restructuring of infrastructure, technology, and fuels. Planning for the increased use of biofuels in transportation entails significant challenges in the conduct of technology development, diffusion and deployment in order to deliver actual benefits to transportation stakeholders.

This preliminary assessment of the program activity in support of biofuels-based transportation, is conducted at a strategic level. That is to say that its focus is on broad opportunities and issues, rather than on details. In addition, it adopts a specialized viewpoint, that of a corporate Product manager, as a means for identifying and assessing critical success factors for the ultimate achievement of program objectives.

For a Product Manager to be effective, there must be a product to be offered on the market. This product needs to be:

- Clearly and simply identified;
- Differentiated from other products by unique benefits;
- Appropriately priced, taking its benefits into account; and
- Reliably available, with an appropriate infrastructure for delivery and service.

Since the biofuels transportation product is to emerge from a lengthy period of development, the timing and cost of that development plan needs to be assured in the eyes of its financial investors.

Normally, potential users and suppliers of the commercial product are deeply involved at the earliest stages of development to maximize the likelihood of success. Accordingly, one would look today to identify those major commercial corporations which will play key roles in transportation biofuels commercialization and deployment. If important benefits for users are foreseen, as well as business opportunities for suppliers and service entities, then an aggressive and vocal program constituency would be expected to exist.

Product development also concerns itself with the state of the market and the likely existence of time constraints on market introduction. Competing concepts are also under development. Windows of opportunity may close. On the other hand, premature market entrance with an unready product and/or underdeveloped market infrastructure may be just as deadly. Development, diffusion and deployment planning should be driven by the physical and time requirements of the processes themselves, not by the availability or unavailability of budgets.

Given the importance of needs - related scheduling, the Product Manager gives considerable thought to the definition of future budget profiles which reflect the changing character and timing of program activities, and seeks to establish a basis for assurance that such future funding levels will be provided over time. Such an effort has a number of key elements:

- It establishes metrics (quantitative measuring points) for future program events, and increases credibility for planning by meeting such measures in the near term;
- It establishes a capability to display anticipated benefits from program success in substantial detail as to source and beneficiaries, on an annual basis, and across all categories of benefits (e.g., jobs, emission reductions, oil import avoidance, and the like); and
- It understands how program costs and benefits can change as a result of changes in key analysis variables, so that market-based and R&D-based feedback loops are in constant application to retune program design and implementation details in accordance with the most recent knowledge and insights.

Barriers to product entry into the market place are accorded equal if not greater attention to development activities. Only some 10 percent of product failures are technically based. Regulatory and financial incentives may be needed to assure secure market entry. The

central focus of deployment is to reduce risk for both users and suppliers, since both must benefit in order for market success to be achieved.

Strategic planning provides a mechanism to establish a vision of a desired future, and the means by which that vision will be pursued. The further discipline of assessing the strategy through the eyes of a Product Manager is an attempt to assure that critical success factors have been identified, and are in place, so that the visualized program benefits can actually be delivered.

2.0 The Biofuels Transportation Product

This assessment of biofuels-based transportation is based on a review of both government and private sector documents, as set forth in the References listed at the end of this report. The relevant government documents include:

- Materials to which the program must conform (such as the Energy Policy Act of 1992, and the current Strategic Plan for the Department of Energy's Headquarters Office of Transportation Technology-OTT); and
- Materials prepared by the program managers which are intended to present and explain program activities and expectations (such as the Biofuels Program Plan: FY 1992-FY 1996).

The relevant non-federal documents reviewed were selected to provide information on how external stakeholders in the transportation arena perceived the possible future use of biofuels-based transportation.

This comparison leads immediately to a focus on definition of the biofuels transportation product.

One method to define a product is in terms of its current usages and embodiment. Some 1 billion gallons of fuel ethanol are produced annually in the U.S., mostly from corn. The

commercial success of this activity relies upon economic subsidy (tax credits) and substantial profits from coproducts. More than a four-or-five fold increase in size could have unacceptable impacts on the grain and coproduct industries. Corn-based ethanol for transportation is what most people know about; however, it does not appear to be the paradigm for the biofuels transportation product of the future.

Another method to define a product is in terms of benefits to be achieved. Biofuels-based ethanol, as a transportation fuel, promises to help reduce oil imports and thereby increase domestic jobs. However, most transportation system competitors (natural gas vehicles, electric vehicles, fuel cell vehicles, high efficiency internal combustion engine vehicles) all promise to deliver the same benefit. Unless biofuels-based ethanol can achieve these benefits more quickly and/or at lower cost, a more unique reason for support of bioethanol is required.

A third consideration in product definition relates to whether the program focus is on an intermediate product (which only offers an opportunity to achieve a benefit) or on a final product (which, if met, would ensure that a benefit is being delivered). The current Biofuels Program Plan addresses a "product line" of diverse opportunity areas: ethanol, methanol, components for reformulated gasoline, biodiesel from aquatic species, and energy crops. External cross-technology comparisons of transportation fuels and systems are, in fact, focused on complete systems and on those technology components which have the largest scale potential for beneficial impact.

Nevertheless, when biofuels-based transportation is assessed in a systems context, there is indeed a clear and significant product that goes far beyond today's applications, offers unique benefits in near- and mid-term time frames, and can provide an integrative center of mass for the overall product line.

Ethanol produced from fast growing renewable energy crops has the highest potential among comparable competing systems to simultaneously achieve significant reductions in

greenhouse gas emissions in the transportation sector and maximize the growth of U.S. jobs in doing so.

A 1993 study by the International Energy Agency (IEA), entitled "Cars and Climate Changes," reports estimated life cycle greenhouse gas (GHG) emissions (in grams per kilometer of $C0_2$ equivalent) for alternative fuel cars in North America as follows:

System/Fuel	Emissions (g/k)
Reformulated Gasoline	263
Ethanol from Corn	260
Methanol from Natural Gas	250
Electric (Current U.S. Average)	244
Compressed Natural Gas	231
Electric (From Natural Gas)	180
Ethanol from Wood	82
Liquid Hydrogen	77
Electric (All Nuclear)	59

While methanol made from renewable energy crops can also yield low GHG emissions, there are two concerns:

- Methanol toxicity may impede its market acceptance as a widely-distributed fuel; and
- The lowest cost methanol may be manufactured off shore from essentially "free" supplies of natural gas, thus undercutting both the intended biofuels foundation and provision of U.S. jobs.

Other concepts which could match bioethanol in beneficial GHG reductions are either in the very distant future (e.g., liquid hydrogen) or require nearly complete conversion of the U.S. electric utility system to all-nuclear or all-renewables forms.

Finally, if the new DOE/industry program to triple the efficiency of the conventional car

were successful, the GHG emissions for reformulated gasoline would still remain well above the bioethanol target because both automotive systems would benefit in efficiency to the same proportionate degree.

Programs aimed at avoiding personal transportation completely (e.g., telecommunication) or in altering its basic structure (e.g., mass transit) are not viewed as comparable competing systems, although their contributions can be very valuable.

Therefore, ethanol produced from fast growing renewable energy crops has the highest potential among comparable competing systems to simultaneously achieve significant reductions in greenhouse gas emissions in the transportation sector and maximize the growth of U.S. jobs in doing so.

3.0 Creating an Informed Constituency

The view of bioethanol as a product with unique potential as a transportation fuel would benefit from greater emphasis in internal program documents, and is essentially missing as an emphasis in external documents.

Even the IEA study referred to in the previous section uses its Executive Summary to point out that ethanol from corn can be higher in GHG emissions than reformulated gasoline, and process uncertainties can similarly make ethanol from wood an undesirable choice. This latter point of view is particularly well exemplified by a quotation widely disseminated through a World Resources Institute publication, but originating in a 1991 publication of a DOE National Laboratory:

"... if wood plantations require a lot of fertilizer, and if the manufacture of materials and equipment results in substantial emissions of greenhouse gases (and if other unfavorable conditions hold), then the biofuels cycles will provide no more than modest reductions -- and perhaps even no reduction at all -- in greenhouse gas emissions."

Other environmental organizations that are active in considering transportation issues, and would reasonably be expected to be advocates of renewables technologies, are similarly ambivalent about bioethanol, also focusing on its corn-based present, and uncertain about its renewables-based future.

Clearly there is a need to create a better informed constituency.

As a prerequisite, however, it is also desirable to consider carefully the particular details of what needs to be communicated. For example, public images of renewables can conceivably be distorted by lack of knowledge of historic and current levels of use, both nationally and globally. Second, biofuels are often associated with non-commercial energy use (as in Africa and India) as compared to commercial systems (producing in excess of 3 percent of U.S. energy in 1990). Information dissemination on wood plantations in use today (by the paper industry), or the Brazilian use of bioethanol, or the several thousand diesel vehicles in Europe operating on biodiesel, all have the potential to alter historic images, and to increase the credibility of today's biofuels transportation story.

The targets of communication are diverse:

- The public through popular science articles, television specials, radio talk shows, and other mass media techniques, to make the strategic vision of commercial biofuels in wide application, and the related benefits, concrete and credible;

- The scientific community to address specific issues which may be generating controversy or disagreements in the assessment process (e.g., ensuring that the energy and cost profiles of energy crop plantations and conversion to transportation fuels are based on development targets and market entry scenarios developed by the program, and not by today's more limited capabilities);

- Regulators, and state officials, to discuss the need for valuing environmental externalities and reducing the commercialization barriers that currently inhibit a more rapid conversion to clean fuels;

- Modelers and policy analysts who are performing cross-technology evaluations and/or charged with evaluating the relative market shares of emerging technologies in future energy systems, to assure that the unique factors supporting expanded biofuels

deployment are in fact captured in their models, and also captured in their analytic outputs;

- Potential industrial partners, to motivate their interests in enhanced cost-shared research and development and CRADAs, as a means of displaying the emergence of active private sector participation in the creation of a new industry;

- Environmental organizations, so that their views of bioethanol are not constrained by its corn-based present, and so that its significant relationship to GHG reduction, both domestically and internationally, is understood and championed;

- Other government agencies such as EPA, AID, Commerce, and Agriculture, to mobilize their special expertise on behalf of understanding the objectives of the program, and helping to communicate it to others; and

- International organizations such as the United Nations, the IEA and the World Energy Council, who have active agendas regarding global environmental issues and the rapidly increasing energy needs of developing countries, to provide and disseminate the support of the international community for commercial and renewable biofuels applications.

The numbers and types of targets could be extended further, and clearly include financing entities of both the U.S. government (e.g., the Office of Management and Budget, and the Congress) and the private sector (banks, including international lending agencies such as the World Bank).

The Biofuels Transportation Program must take the lead in defining those elements of the communication message which are descriptive of its vision and strategy. However, it is likely neither feasible nor appropriate for it to undertake the actual distribution of this assessment entirely on its own. A desirable communication strategy would seek to multiply program efforts through the activities of others. For example, the industrial community that plans to create the new biofuels industry would be expected to establish an industry-based information program of its own. The Department of Agriculture might already have in place the most effective delivery mechanisms to communicate with the American farmer. Program involvement in international agency Working Groups could be used to motivate those organizations to address program needs, thus leveraging the application of U.S. resources.

Public meetings, to obtain stakeholder input on program design and implementation, can be

directed towards the general public, the regulatory and financial communities, and potential industrial partners. Such meetings can be invaluable in building consensus, defining a program consistency, and obtaining feedback on the effectiveness of previous communication efforts.

Indeed, effective feedback loops are an essential element of the Product Manager's approach to understanding the market place, and ensuring that the product design is attuned to its requirements.

Fulfillment of the biofuels transportation development, diffusion and deployment plan involves interactions that go beyond joint activities with cooperating entities. Competition acts as a driver in the marketplace, as well. An awareness of the status of the development of biofuels by other stakeholders is crucial to attain or keep an edge in the competitive market. Some of the following illustrative stakeholders in the biofuels market are cooperators; some are competitors. All are involved in one way or another in influencing the status and future of the program:

A. Federal departments and agencies

1. Department of Agriculture
   Office of Energy
2. Environmental Protection Agency
   Fuels Studies and Standards Branch
3. Department of Transportation
   Research & Special Programs Administration
4. Department of Commerce
   National Institute of Standards and Technology
5. Department of State

B. CRADA Participants

1. New Energy Company of Indiana, Inc. (NEC)
2. Amoco Oil Company

C. Congressional Constituents

1. Research centers (universities, independents)
2. Agriculture Industry
3. State governments
   a. Governors Ethanol Coalition (Nat'l Governors Assoc.)
4. Local governments/municipalities (MSW)
5. Consumers/Consumer advocates
6. Environmental groups
7. Corporations
   a. Automobile manufacturers
   b. Oil companies with limited access to crude oil reserves
   c. Large-scale farming complexes
   d. Pulp and paper industries
   e. Chemical manufactures
   f. Commercial processors of MSW and other waste materials
8. National Laboratories/Research Institutions

In order to identify a range of possible program constituents, a search through the Research Centers Directory (15th edition, 1991) revealed there are 43 research facilities working in the area of "biomass energy" in the U.S., Canada, and Puerto Rico. Of these, 33 are universities, 3 are independent, and one is a Federal center (the USFS). They are located mostly in the southwest (14) and south (11). Typical sources of support include state government, endowment, parent institution, industry, foundations, U.S. government/federal departments or agencies, grants, contracts, local government, and individual gifts.

In the description of "Research activities and files," these research centers list biomass utilization, energy-yielding biomass, biomass for energy, forestry and wood biomass energy, fuel biomass research, and biomass energy conversion -- among other phrases -- as one of the research areas. Few facilities concentrate on biomass fuels alone. The facilities are grouped with other biological, environmental, agricultural, or engineering facilities. Most facilities are staffed with a combination of research professionals, faculty members, support staff, technicians, visiting scholars, graduate students, and others.

Corporations are considered main constituents. In the 1993 Thomas Register, 14 manufacturers of methanol are listed, with profits ranging from $1 M to $100 M (Alberta

Gas Chemicals). Eight manufacturers of "alcohol: ethyl" are listed, with profits up to $50 M+. By far the major producer of ethanol is Archer Daniels Midland, though there are rivals like Cargill, Bunge, and Continental Grain.

ADM is active in such organizations as the Renewable Fuels Association and National Corn Growers Association. The effort has paid dividends. Today the success of two of ADM's major products, the motor fuel additive ethanol and fructose corn sweetener, derive not only from ADM's efficient processing of corn starch but also from tax subsidies and sugar import quotas validated through legislation.

Currently the value of U.S. biofuels technologies exports is small, but the potential market for such technologies is huge. U.S. producers are primarily focused on the domestic market; however, technology and equipment suppliers and the service industry can focus on export markets as well. The Program Plan states, "The success of the BSD program will help achieve many of our national priorities including the goals set forth in the *National Energy Strategy*, the Alternative Motor Fuels Act (AMFA) of 1988, and the Clean Air Act Amendments (CAAA) of 1990." Among the goals set forth in the legislation is the creation of U.S. jobs -- thus the effort to create regional biofuels industries, for example. Therefore, a focus solely on domestic self-sufficiency may prove to be unnecessarily limiting in the long run. The Clinton administration, in its Climate Change Action Plan (CCAP) emphasizes "the twin challenges of responding to the threat of global warming and strengthening the economy" (p. i). The administration seeks to enhance "prospects for economic growth and job creation, and position our country to compete and win in the global market." While a healthy domestic market for biofuels and a productive domestic biofuels industry -- a sustainable U.S. biofuels demand and supply economy -- are both reasonable goals, the experience base which this generates should have global application.

Within the U.S. government, there appears to have been little effort to date to expand biofuels production and processes to international markets. Government programs have focused on developing the U.S. biofuels economy. With the introduction of the North

American Free Trade Agreement (NAFTA), however, interest in biofuels expressed by foreign governments such as Japan, and increasing needs in the developing world, the opportunity for expanding U.S. jobs, and thereby program benefits, through technology export may merit additional consideration.

The regional character of program participants and supporters in the U.S. is also important. There are differences in regional potential for the production of energy crops or the utilization of waste residues. However, the transportation-based benefits can be wide spread. Also, the potential for contributing to technical advances in the various system stages (crop development, harvesting, feedstock pretreatment, conversion, infrastructure development, distribution, end-use systems specifically designed for ethanol and biodiesel) knows no regional boundaries. An aggressive search (e.g, through a Program Opportunity Notice) could serve to bring new elements into the program, and, at the same time, provide a mechanism for speaking to an expanded audience.

A broader regional focus will also facilitate engaging the interests of states and local communities who can, in turn, provide valuable program design input, and help expand the network of communications and constituents.

4.0 Concreteness, Credibility and Integration

Concreteness, Credibility and Integration require an ability to describe not only the attributes and benefits of a delivered system, but also the ability to visualize how that system will evolve from today's situation.

The National Renewable Energy Laboratory currently has plans to conduct a major policy analysis of the relative costs and value of bioethanol over time, and to relate this information to market penetration scenarios and time-based quantification of technology diffusion and

deployment. Such analytic projections are extremely valuable in helping to make program thinking concrete to others.

A related essential element of near-term program activity and self-description is the visualization of the means for market entry into near-term niche opportunities. While it may still take a decade for the elements of a future biofuels system to obtain their final market structure, near-term entry to meet specialized needs should enhance credibility and improve understanding of the longer-term structure and benefits.

The primary delivery system used to assess program products is the biofuels production life-cycle, comprised of individual and interrelated subsystems:

Biofuels Production Life-Cycle System

Biomass Feedstock Subsystem	→	Harvesting Subsystem	→	Preparation Subsystem	→	Delivery & Storage Subsystem	→	Conversion Subsystem	→	Distribution Subsystem	→	Utilization Subsystem

In order for biofuels transportation products to be delivered (and thereby generate benefits) a fully functioning biofuels products system with all of its subsystems must eventually be brought into operation. Today, different pieces of those subsystems are in place serving biofuels requirements, some functioning under market conditions, others subsidized by federal and state tax credits. Subsystems, analogous to those needed to serve biofuels, are in place but serving other products in the market.

Creating the subsystems required to support biofuels products is resource-intensive. Obviously, multiple subsystems to support all alternative transportation fuel competitors will not be built. Investors will be drawn to those concepts which offer a unique product--superior to existing products and competing alternatives with low-risk and high-returns on investment.

Niche market opportunities can help to establish functioning components of needed infrastructural elements, critical to displaying the concreteness and credibility of future system expansion.

This need for near-term niche utilization based on renewable energy feedstocks may find openings of diverse character. If pulp and paper companies which currently grow forestry products for internal use can be motivated to explore diversification, the practicality of the integration of feedstock and conversion will be more clearly demonstrated. If current processors of municipal solid waste (MSW) can similarly be motivated to explore diversification, the opportunities and economics for niche market entry through this pathway might be better understood. (For example, Ogden Corporation currently operates 24 projects, converting MSW to electricity on a commercial basis. See also the MSW industry characterization in Appendix B). If a greater number of neat ethanol vehicles (or flexible-fuel vehicles which can use ethanol) are brought into Federal fleets or other alternative fuel demonstration fleets, the performance of such vehicles, including their emissions, can be better validated. If a single large integrated farming combine with marginal crop-land holdings can be motivated to explore diversification, the reality of its involvement would possibly offer significant program benefits.

Another near term opportunity resides in the potential for ETBE (an ethanol-based ether) to be adopted as a renewable-source oxygenator for reformulated gasoline. Current program activity is fully aware of the importance of this opportunity to assist in the creation of near-term markets. The problems currently being encountered in achieving this outcome are a good illustration of the criticality of pre-market efforts to gain constituency (e.g., EPA, environmental organizations, potential industry suppliers), to inform the public, and to have addressed the concerns of critics well in advance of the final decision-making process.

Still another opportunity for near-term program visibility resides in President Clinton's Climate Change Action Plan. A biofuels transportation component is not presently included, although numerous supporting mandates and authorities for program maturation exist in the

National Energy Policy Act of 1992 (See Appendix A). It may be desirable to view the door to involvement in this effort as still open. Public review is expressing the need for additional elements. A well-quantified proposal may yet allow for program inclusion in a later version of this plan.

The key connection between bioethanol's ability to contribute positively to GHG mitigation and current economics which do not yet place an explicit value on this benefit, also reinforces the need to define more clearly and communicate the relevance of environmental externalities as a public policy forcing function. Numerous external studies are analyzing this situation. The Public Utility Commissions in several states are formally requiring that decisions on new electric generation capacity incorporate such considerations. However, current DOE policy models (such as the NEMS, discussed in Appendix C), do not take formal cognizance of this barrier to the commercialization of clean fuels and technologies. This situation also presents an important opportunity for the program to explore how its fundamental values can be given increased visibility and credibility.

Because the Biofuels Transportation Program consists of a large number of related but disparate elements, as well as a main product (bioethanol) associated with a renewable product line (biodiesel, ETBE), the value to be ascribed to increased integration of the various elements is judged to be high.

Areas where greater integration may improve concreteness and credibility include:

- Integration of biomass feedstock and conversion. These subsystems are highly inter-related, both in terms of technology development and the economics of biofuels production. R&D goals and R&D products--and their precise properties--clearly benefit from formal coordination among organizations and researchers working in these two areas. Without a coordinated integrated research agenda, solutions may be developed to solve problems that are peripheral to primary system development; requirements for feedstock characteristics which may be assumed in the conversion subsystem may differ from those being developed for the biomass feedstock subsystem. Areas which may merit particular attention include harvesting, distribution, joint economics of a vertically integrated supply system, and the relationships between feedstock properties and conversion pretreatment.

- Integration of biofuel characteristics (e.g., ethanol) with the design of optimized flexible fuel and neat methanol vehicles in terms of emissions and performance characteristics. (This also suggests the possible importance of program integration with the activities of the NREL Alternative Fuel Data Center).

- Integration of biomass production R&D with biomass harvesting issues. Biomass production losses due to shortcomings in harvesting technology can eclipse marginal advances made in increased biomass yields.

- Integration of program activities with other countries and international organizations addressing biofuels through international cooperative activities. (Research conducted by other countries may have domestic value. The way in which commercialization barriers in Brazil and Europe were addressed may suggest useful elements of a U.S. deployment strategy).

- Integration of technologies currently being developed for other markets that might be used in biofuels product production. For example, fermentation for biotechnology products or processed food products, feedstock separation technologies for MSW, installation technologies for alcohol and petroleum-based products. Firms involved in these activities are candidates to conduct technology requirements applicable for biofuel products. These companies are potential vendors to the future biofuels product industry. Alternatively, there may be spinoff values for biofuel technologies to other applications.

- Integration of the development scenario, and its progression down the cost-reduction scale, with the benefits arising from the diffusion and the deployment scenarios. While such improved integration is currently scheduled to occur, through the planned technology penetration studies, an additional focus might be given to the time-sensitivity of benefits. Program materials available for review did not indicate the degree to which current development and economic timetables are resource- or risk-constrained. Nevertheless, it is clear that windows of opportunity exist, both with respect to the timetable for competing transportation concepts and for GHG reduction benefits. It is also unclear, given the significant infrastructure needs, whether the critical path for benefit delivery is through the R&D chain, or through the rapid growth of near-term niche markets.

5.0 Partnerships and Timing

The four critical success factors identified in this preliminary assessment are:

- **Defining the uniqueness of the biofuels transportation product;**

- **Building an informed constituency;**

- **Emphasizing concreteness, credibility and integration in the program design and implementation; and**

- **Near-term attention to partnership and timing.**

There are interrelationships among all of these elements, and various aspects of partnerships and timing have already been discussed. This section of the report, however, revisits this subject area to suggest some additional ideas.

All four of the above critical success factors originate in the desire of a Product Manager to be able to obtain needed resources (people, facilities, budgets) to complete the technology development and diffusion processes, and bring the product to market.

While the acquisition of resources is at one end of the strategic planning and product development processes, assurances as to benefit delivery are at the other.

Because market forces are in constant flux, and because the availability of scarce resources is in constant demand, timing is critical. Priorities, once allocated, are difficult to revise. Public attitudes, once established, may take decades to change. There is a human tendency to act along the lines of perceived group consensus. Therefore, the time lines of the biofuels transportation program need to reflect not only technical necessities, but also the laws of the market place, the investment community, and public understanding. The industrial partnerships of a future biofuels industry need to become highly visible, and visible now.

Recognizing that much progress has already been made in these directions, and more is in progress, the following additional suggestions are offered for consideration.

- Enhanced industrial and institutional support of biofuels may be facilitated by noting that a number of competing transportation system concepts are not necessarily in competition with an expanding biofuels industry, and may even benefit thereby:

    - The biofuels target for oil reduction is crude oil imports and petroleum product imports. Limitations on land use probably ensure that a substitution of ethanol for domestic oil production is a very distant event, if it ever were to appear feasible or

desirable. Imports are expected to be an increasing component of oil use for a number of decades. Therefore, the domestic U.S. oil industry support of biofuels development could be both rational and mutually beneficial;

- Electric vehicles (because of range limitations) are expected for many years to seek a mass market based on hybrid vehicles which still require a liquid fuel component. There is thus an argument that hybrid engines might be optimized for ethanol, not gasoline;

- Fuel cell vehicles still require a source of hydrogen. Planning is based on methanol, and engenders concern regarding methanol toxicity and overseas supply sources. In any event, there may be some possible near-term synergism with biomethanol or bioethanol, with the ultimate fuel cell target being a long-term capability to utilize hydrogen directly; and

- As noted previously, the DOE/industry CRADA activity on enhanced automotive efficiency could possibly get even more "bang for the buck" if it incorporated biofuels as an integral element.

- Based on the above examples, and others cited below in the discussion, there may be opportunities to open up additional sources of funding support for biofuels technology and fuels development. Immediate candidates at the Federal level are Transportation, Agriculture, EPA, Defense (and ARPA). The latter entity has already provided significant funding for electric and fuel cell vehicles associated with defense conversion interests. There is certainly the basis for a defense mobility interest in an enhanced domestic transportation fuel source, particularly as U.S. oil production continues to decline. Expenses associated with the maintenance of a Strategic Petroleum Reserve may be reduced (or present oil stocks turned into deficit-reduction cash) as a domestic biofuels industry takes shape. Individual states provided state funds to support clean coal technology development, as the regional significance of program success in this area became evident to them. Commerce, AID or the Trade Development Program might provide funds to assist in international technology collaboration, or to aid U.S. firms with biomass capabilities to market their knowhow abroad.

- CRADAs are often seen as an indication of industrial interest. The biofuels program could seek to stimulate a large number of such cooperative relationships with numerous small entities for modest and exploratory levels of program activity (as compared to a few very large events with large corporations). Such activity might constitute a basis for many different companies to establish a role and a stake for themselves in an emerging industry. The target areas might be components (fermentation tanks, valves, harvesting equipment) rather than entire systems. Consortia (collections of companies with synergistic interests) could be an additional target. Direct program funding of state universities might aid in getting a knowledgeable program voice into state-level decision making.

- Small companies, other than the big three auto manufacturers, might be targeted for involvement in bioethanol car design, automotive components, and engine optimization. The NREL agreement with the Southwest Research Institute for this purpose is commendable. However, the degree to which this effort will reach through the Institute and into the industrial community is unclear. By comparison, the electric vehicle and fuel cell vehicle world has a number of non-Detroit companies vying for a role in a future manufacturing industry.

As an illustration of the activity of state funding sources, the involvement of numerous entrepreneurial organizations, and an attack on infrastructure requirements in parallel with fuel and vehicle development, some experiences related to methanol and CNG offer interesting insights.

As of February 1992 there were expected to be 33 service stations dispensing M-85 in California. The California Energy Commission then announced plans to install 10 new methanol stations each quarter. The California Public Utilities Commission, which evaluates utility applications for rate increases, is also doing its part to promote gasoline alternatives. In a case involving Pacific Gas and Electric Co., the commission authorized a two-year $18 million program that includes construction of 25 natural gas fueling stations. Pacific Gas also announced plans to offer individual incentives of $1250 toward the conversion of a gasoline vehicle or purchase of a dedicated natural gas-powered vehicle. The California Public Utilities Commission also authorized a two-year $6.7 million program for San Diego Gas & Electric. This program involves construction of two natural gas fueling stations and conversion incentives of up to 50 percent of the conversion cost, for about 400 conversions per year.

With the competition between alternative fuels, electric cars, and other new transportation technologies, bioethanol must develop an edge and a strategy to stay ahead.

Near-term opportunities are indeed believed to exist based on the possibility of non-grain feedstocks which may be available at no or low cost. In many cases, these are agricultural residues or other waste materials whose current means of disposal may face increasing

limitations and costs. The National Renewable Energy Laboratory has noted the following as potential domestic biofuels feedstocks, in addition to the energy crops that might be produced on 190 million acres of land in the U.S:

- Underutilized wood and logging residues comprising an annual resource of 100 to 280 million tons;

- Agricultural residues, comprising an annual resource of 95 million tons;

- Municipal solid waste, comprising an annual resource of 200 million tons, and steadily increasing in magnitude; and

- Industrial wastes comprising 12 billion tons annually of wastes requiring treatment and disposal.

Clearly, not all of these materials will be suitable, technically and economically, for processing. However, the near term target does not need to be volume-oriented; rather the objective would appear to be the stimulation of actual private sector involvement and activity in the continuing growth of biofuels production from renewable sources, and the distribution and use of that product to meet ongoing energy needs.

To sustain program support through the remaining period of development of improved technology, the current image of a lengthy R&D process, which is simply in competition with other concepts offering similar benefits, needs to be replaced with the aggressive pursuit of near-term actions to establish a future industry, with widely understood and unique contributions to the nation's future well being.

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Appendix A

Biofuels Authorities of Energy Policy Act

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Biofuels Authorities of Energy Policy Act

The National Energy Policy Act of 1992 (EPAct) provides numerous authorities and mandates which affect the biofuels program area. The Act amplifies previous elements of the National Energy Strategy, the Clean Air Act Amendments of 1990, and the Alternative Motor Fuels Act (AMFA) of 1988 in this regard. EPAct emphasizes development of economically viable and environmentally friendly energy sources. Biofuels provisions cover a range from market incentives to biofuels research goals. EPAct specifically addresses biomass-based ethanol, methanol and biodiesel. The legislation outlines activities for agencies in addition to DOE, and provides for substantial outyear budget authorizations to undertake a number of biofuels initiatives both domestic and international. A summary of key provisions and available status information is presented below.

Title/Section	Provision	Program Status
Title III Sections 302 & 303	**Minimum Federal Fleet Requirement** Federal fleet to purchase at least 25% vehicles that operate on domestic alternative fuels by FY96; purchase AFVs to reach 75% by 1999. DOE must issue guidance on how agencies should implement these provisions.	Five thousand alternative fueled vehicles will be added to Federal fleet in FY93
Title III Section 304	**Refueling** must, to extent practicable, be at or by commercial facility. Federal government can enter into arrangements in area lacking supplies.	
Title IV Section 405	**Public Information Program** for the purposes of promoting use of alternative fuels and AFVs to be established by Secretary. Within 18 months of enactment, information package for consumers regarding the above to be made available.	DOE is coordinating with EPA to produce an information package on alternative fuels and AFVs.
Title IV Section 407	EIA **Data Acquisition Program** within one year of enactment in at least five diverse regions. Data addressing: # and types of AFV trips; projections of most likely combination of AFVs use; cost, performance, environmental, energy, safety; and other demographic information.	

Title/Section	Provision	Program Status
Title IV Section 409	**State and Local Incentives Program** Authorizes up to $10 million annually (FY93-97). Secretary to issue guidelines 1 year after passage. Review and advise (with DOT and EPA) within one year of guidelines on State plans to encourage AFVs.	Regulations for State alternative fuel and vehicle incentives and plans delayed 8 months to June 1994 due to lead time necessary for the rulemaking process.
Title IV Section 412	Study impact of alternative fuels usage by **non-road vehicles and engines** to be completed within 2 years after enactment.	
Title IV Section 414	**Low Interest Loan Program** Secretary to make low interest loans, with preference to Small Businesses, for fleet conversions or purchases. $25 million authorized for FYs '93-'95.	Loan program moderately delayed due to insufficient funding and staff.
Title V Section 501	**Mandate for Alternative Fuel Providers** Secretary to issue regulations providing that Covered Persons (CP) fleets acquisitions be 30% AFVs by Model Year 1996 and 90% by MY99. CPs include U.S. fuel processing, transporting, importing firms and utilities.	Alternative fuels providers program hampered due to lack of funding that would be provided by stimulus package and time necessary for issuing regulations.
Title V Section 507	**Fleet Requirement Program** Fleet purchase goals for non-Federal, state and CP fleets shall be 20% AFVs in MYs 1999, 2000, and 2001 rising to 70% by MY 2005.	"
Title XII Section 1202	**Renewable Energy-Demonstration and Commercial Application Projects** A 5 year program ($50 million authorized for FY94) for demonstration projects in renewable energy and energy efficiency (includes: A) Conversion of cellulosic biomass to liquid fuels. B) Ethanol and ethanol byproduct processes. C) Direct combustion or gasification of biomass. D) Biofuels energy systems). Mandates joint demonstration and commercialization with the private sector.	Business planning for possible demonstrations is underway.
Title XII Section 1202	Forms an **Advisory Committee on Demonstration and Commercial Application of Renewable Energy and Energy Efficiency Technologies** (NREL represented). Advisory Committee to provide Secretary a report assessing implementation 18 months after passage.	
Title XII Section 1202	**Specific Ethanol Goals** I) reduce cost of alcohol to 70 cents a gallon, II) improve biomass carbohydrate conversion efficiency to 91%, III) reduce capital cost component to 23 cents, IV) reduce O&M cost component to 47 cents a gallon	

Title/Section	Provision	Program Status
Title XII Section 1202	**Specific Methanol Goals** I)reduce cost of alcohol to 47 cents/gallon, II) reduce capital component to 16 cents/ gallon	
Title XII Section 1202	Inserts **Biodiesel Energy Systems** under Biofuels Energy Systems	
Title XII Section 1202	**National Renewable Energy and Energy Efficiency Management Plan** Requires revised management plan to Congress containing program needs, objectives and priorities for each of the programs covered by the Act within one year of passage and every three years thereafter.	
Title XII Section 1211	**Innovative Renewable Energy Technology Transfer (TT) Program** Authorizes $100 million for FY93-98 to create TT projects, through AID, intended: to reduce the balance of trade, retain and create jobs in the U.S., encourage the export of U.S. technology and related services, develop markets for these technologies, assure effective U.S. participation in Foreign energy projects, assure introduction of U.S. firms into foreign markets, provide U.S. governmental financial assistance in renewable energy technologies in foreign countries, assist foreign countries in meeting their energy needs, and assist U.S. firms to obtain opportunities in foreign countries.	
Title XIX Section 179A	**Tax deduction for clean fuel vehicles and refueling facilities up to:** $2,000 for cars, $50,000 for trucks 50K lbs. for the taxable year vehicle placed in service. Up to $100,000 for refueling properties. Phase out 25% in 2002 through 100% in 2005.	
Title XIX Section 1920	**Reduced tax rate on gasoline mixed with alcohol.** 10% (3.5% oxygen level) 6.1 cents gallon; 7.7% (2.7% oxygen level) 7.342 cents gallon; 5.7% (2.0% oxygen level) 8.422 cents gallon. Effective 12/31/92.	
Title XX Section 2023	**Alternative Fuel Vehicle Program** Secretary to create a RD&D program (ranging from fuel injection to emissions control for vehicles and advanced storage systems) in AF transportation-related use. Research conducted under cost share arrangement.	

Title/Section	Provision	Program Status
Title XX Section 2024	**Biofuels User Facility** The Secretary shall establish a Biofuels user facility to expedite industry adoption of biofuels. Through colleges and universities, the Secretary shall establish a program addressing production and use of diesel fuels from vegetable oils or animal fats. Includes study of small-scale oilseed pressing and esterification unit.	
Title XX Section 2027	5 year **Advanced Diesel Emissions Program** to address diesel engine combustion and engine systems, related advanced materials, and *fuels (including biodiesel)* and lubricants to reduce emissions of oxides of nitrogen and particulates. Program plan to be submitted within 180 days of enactment.	

Appendix B

Characterization of Municipal Solid Waste

Appendix B

Characterization of Municipal Solid Waste

Quantities of municipal solid waste (MSW) have grown rapidly during the past three decades - from an estimated 88 million tons in 1960 to about 196 million tons in 1990 - and are projected to grow to around 220 million tons by 2000.[1] The heat value of a typical pound of MSW has also increased - from an estimated 3,774 British Thermal Units (Btu) per pound in 1960 to about 5,110 Btu per pound in 1990 - due primarily to an increase in the disposal of paper and plastics. By 2000, the Btu value of MSW could exceed 5,500 Btu per pound based on a continuation of recent historical trends.[2]

Increasing quantities and heat values of MSW, coupled with greater difficulty in siting landfills, have increased the variability of utilizing MSW as a fuel to produce electricity and steam. According to one estimate, the number of U.S. municipal landfills has decreased from 8,000 in 1988 to 5,812 in 1990 - a 27 percent drop.[3] While trends in total landfill capacity are subject to debate, there is little questions that the cost of landfilling MSW has and will continued to increase significantly. These cost increases are a result of more restrictive rules on the siting and operation of landfills, which have been imposed by the Environmental Protection Agency (EPA) to control pollution runoff into surface and groundwater.

Although incineration of municipal waste has long been used as a method to manage MSW, the retrieval of energy from incineration has occurred only recently. As of 1960 there was no incineration with energy recovery in the United States. By 1980, 1.8 percent of all MSW

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1 Environmental Protection Agency, *Characterizations of Municipal Solid Waste in the United States: 1992 Update*, EPA/530-R-019, Washington DC, July 1992.

2 Curlee, T. Randall. "Projections of Energy from the Combustion of Municipal Solid Waste: 1993 DOE-AEO Update." Draft report prepared for the Energy Information Administration, U.S. Department of Energy, July 1992.

3 Flenn, J., "The State of Garbage in America," *Biocycle*, April, 1992, pp. 46-55.

was burned with heat recovery. A rapid adoption of waste-to-energy (WTE) technologies during the 1980s increased that percentage to 16 percent of all MSW in 1990.[4]

As of 1990 there were about 140 WTE facilities operating in the United States. An additional 62 facilities were in the advanced stages of development or under construction. In 1990 the Southern States had the largest number of existing facilities (36.4 percent), followed by the Northeast at 28.6 percent, the Midwest region at 23.6 percent and the Western region at 11.4 percent. If existing facilities and facilities in the advanced-planning and construction phases are summed, the Northeastern region has the largest percentage of WTE facilities at 36.1 percent. The Southern region is in second place at 31.7 percent, followed by the Midwest region at 21.3 percent and the Western region at 10.9 percent.[5]

WTE technologies are generally divided into 2 or 3 types. Virtually all units use either mass burning or refuse-derived fuel (RDF) designs. Mass burn technology is further divided into waterwall furnaces and modular designs. Mass burn waterwall furnaces are large custom-designed plants that process raw waste with little or no sizing, shredding, or separation. Approximately 51.4 percent of all facilities in the construction, advanced-planned, and operational phases employ some form of mass-burn technology. Modular (mass burn) facilities are much smaller and are usually pre-fabricated. They are more likely to produce steam only and may employ a second stage combustion chamber. Modular technologies are used by 26.7 percent of the units. In RDF technologies, wastes are pre-processed via separation and shredding to produce a more homogeneous fuel than raw MSW. This product is then either sold to an outside customer (such as a utility) or burned in a dedicated furnace. Approximately 21.4 percent of facilities produce RDF. With respect to energy production, 52.0 percent of all existing and planned facilities in 1990 produced or were designed to generate only electricity. Steam and hot water were produced exclusively at 28.3 percent

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4 Op. Cit., EPA.

5 Government Advisory Associates, *Resource Recovery Yearbook*, various issues, New York, NY.

of all facilities, and 19.2 percent of facilities co-generated steam and electricity. With respect to those facilities being constructed or in the advanced-planning stage, 77.4 percent will produce electricity exclusively. Only 4.8 percent will produce steam exclusively, and the remainder will co-generate steam and electricity. The average capacity for all existing and advanced-planning facilities is 33.5 megawatts (MW) with a range of 0.27 to 364 MW. Planned facilities will be larger in size and have an average capacity of 37.4 MW.

Within the United States, an average of 485 net kilowatt-hours of electricity are produced for every ton of MSW burned. The average design capacity for all existing and planned facilities is 792 tons per day, with a range of 13 to 4,000 tons per day. Considering only the advanced-planned facilities, design capacity is about 1,100 tons per day compared to 656 tons per day for existing facilities.[6] Considering electricity, steam, and RDF production and methane from landfills, the total production of energy from the combustion of MSW in 1990 was about 0.4 quads - a small share of total U.S. energy consumption.[7]

The future for MSW as an energy resource is controversial and very uncertain. The rapid growth of the WTE industry in the 1980s was the basis of the 1991 EIA projection that WTE would account for as much as 50 percent of all MSW by 2005 and result in the production of about 1.3 quads of energy.[8] However, this projection now appears optimistic, given increasing WTE project cancellations. Between 1983 and 1984 only eight WTE projects in the United States were canceled during their conceptual or advanced-planning stages. By 1986 an additional 74 planned facilities had been abandoned, and by 1989 another 78 had been added to the list. Between 1989 and 1990 the rate of cancellation escalated further, as an additional 121 facilities were scratched (information derived from

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6 Ibid.

7 Energy Information Administration, *Annual Energy Review 1991*, DOE/EIA-0384(91), Table 108, p. 245. (Washington, DC, June 1992).

8 Energy Information Administration, *Annual Energy Outlook 1991*, DOE/EIA-0383(91), Table A6, p. 50 (Washington, DC, March 1991).

Government Advisory Associates, 1982, 1984, 1986-87, 1988-89, and 1991). The causes of these cancellations are varied; most are driven by perceived environmental or economic impacts on host communities. These numbers must be compared to a total of only 140 existing facilities in 1990.

Very few forecasts of WTE beyond the year 2000 are available. Steven Levy of the U.S. Environmental Protection Agency (EPA)[9] reported that WTE facilities were used for the combustion of about 16.9 percent of all MSW in 1991 (assuming that 90 percent of available capacity was utilized and MSW totalled 200 million tons). In their 1992 document, EPA projected that WTE would account for only 17.0 percent of MSW by 1995, increasing to 20.8 percent by 2000.[10]

In very broad terms, however, there are five major trends pointing toward the greater use of WTE. First, the number of landfills is dropping rapidly and will continue to do so as recent Resource Conservation and Recovery Act (RCRA) landfill rules are put in place. Although the amount of projected landfill capacity is unknown at this time, the cost of landfilling is likely to increase significantly in absolute terms. Second, in the past there have been restrictions on the capabilities of local and State government to issue tax-exempt financing for large WTE projects. These obstacles to the financing of WTE facilities, resulting primarily from the 1986 Tax Reform Act (TRA), are likely to be overcome gradually as amendments to the tax act are adopted and new financial instruments are developed to overcome imposed barriers. Barriers imposed by the TRA and the cost of new requirements for pollution control on WTE facilities may have played a major role in the recent cancellations of WTE facilities. Third, the environmental effects of WTE continue to be assessed, and the public opposition to WTE may subside somewhat as the public becomes more informed about the environmental consequences of WTE relative to other management

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9 The EPA maintains a data base of all planned and operational WTE facilities.

10 Op.Cit., EPA, Table 34, pp. 4-18.

options. Fourth, there is the possibility that recycling goals (often in the range of 25-50 percent) mandated or targeted in many States will not be reached, thus causing communities to turn increasingly to WTE as an alternative. Finally, it is possible that legislation will be implemented to grant States limited authority to restrict the importation of MSW into their States for disposal. Recent attempts by States, such as Alabama and Indiana, to restrict the importation of waste have thus far been overturned in the Courts on the grounds that such bans violate the interstate commerce provisions of the U.S. Constitution. If, however, the federal government allows States to limit the interstate transport and management of MSW, many populous States will be faced with the increased burden of managing their own waste. In this event, WTE is likely to receive greater approval from the public and local decision makers.

On the other hand, there are reasons why the growth of the WTE industry could be limited. While some environmental concerns could be alleviated, public opposition may have a substantial impact on future industry growth. The energy saved as a result of some recycling, such as paper and plastics, is much greater than the energy available from burning the waste. One recent study estimates that energy conservation from recycling averages about 2,150 kwh per ton for typical residential waste, or more than 4 times the average amount of energy obtained from combustion.[11] As the infrastructure for recycling is gradually developed, and product and packaging designs are modified, waste reduction and recycling rates should continue to improve. Considerable attention has recently been placed on composting of organic materials as a means of managing a large fraction of the waste stream. In the longer term, other potential technologies may displace the current combustion type plant. Production of low-Btu gas or ethanol may prove more economical and environmentally desirable.

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[11] Morris, J. and Canzoneri, D., "Comparative lifecycle energy analysis: theory and practice," *Resource Recycling*, November 1992: pp. 25-31.

Because of these significant uncertainties about how much WTE will penetrate as an acceptable MSW disposal option, it will be important to identify underlying assumptions when defining the trend of the waste combustion share under various scenarios.

The DOE Energy Information Agency recently published an article on municipal solid waste in the U.S. and found no current commercial conversion of the biomass portion of MSW to ethanol but did state that "biological conversion to methane or ethanol are in various stages of development and could be effective conversion techniques in the future[12]." A major EPA study titled *Characterization of Municipal Solid Waste in the United States: 1992 Update* does not even mention the current or future possibility of conversion to ethanol[13].

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[12] Carlin, John, *Municipal Solid Waste in the U.S. Energy Supply*, DOE/EIA, Electric Power Monthly, October 1993

[13] Op cit. 1

Appendix C
National Energy Modeling System (NEMS)
Treatment of Bio-Fuels

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National Energy Modeling System (NEMS)
Treatment of Bio-Fuels

Background

The National Energy Modeling System (NEMS) is a computer-based, energy-economy modeling system of U.S. energy markets for the mid-term period of 1990 to 2010. NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS was designed and implemented by the Energy Information Agency (EIA) of the U.S. Department of Energy (DOE) for preparing baseline forecasts of domestic energy markets and analyzing the potential impacts of proposed government policies and of alternative energy market assumptions.

The forecasts produced by NEMS are not considered to be absolute predictions of the future but are contingent on the key assumptions made about U.S. energy systems. Contingencies include, for example, the estimated size of the economically recoverable resources base of fossil fuels; changes in world energy supply and demand; the rate at which new energy technologies are developed and the rate and extent of their penetration into commercial markets; and existing or prospective government actions or policies. NEMS provides a consistent framework representing the complex interactions of the U.S. energy system and its response to a wide variety of alternative assumptions and policies, without attempting to determine which of many plausible energy futures is most likely to occur.

NEMS was built to support energy policy analysis and to serve as an important resource for the development and analysis of the impact of alternative energy policies on key U.S. markets and economic growth. NEMS was formulated with three objectives:

- To provide sufficient modeling detail to support a broad range of policy analyses;
- To capture the important interrelationships in the U.S. energy markets in order to simulate the response of the entire energy system to changes in market conditions;
- To facilitate the development, maintenance, and use of the energy modeling system.

As a tool for policy analysis, NEMS was designed to simulate those aspects of the energy system to which policy initiatives are most likely to be directed. For example, environmental issues related to energy production and consumption have become a high priority in recent years. Accordingly, NEMS, unlike EIA's earlier modeling systems, has the capability to estimate the levels of key emissions from the production and use of energy, and to model the changes in emission levels that are likely to result from such government policies as the provisions of the Clean Air Act Amendments of 1990. For similar reasons, NEMS contains sufficient detail in both the refining (supply) and transportation (demand) sectors to analyze both the costs and likely market penetration of alternative or reformulated fuels.

In addition to environmental concerns, NEMS can be used to analyze the effects of existing government regulations and proposed regulatory reform related to energy production and use; the potential for the development and use of new energy production, conversion, and consumption technologies; the impacts of increased use of renewable energy sources; and the potential savings from demand-side management and increased efficiency of energy use. Other examples of energy topics that reflect the expected scope of the present and future government policy, all of which can be addressed by NEMS, include the following:

- Impacts of energy tax policies on the U.S. economy and energy systems
- Response of the electric utility industry to limits on SO_2 emissions and the allowance trading program of the Clean Air Act Amendments of 1990
- Responses of the energy and economic systems to changes in world oil market conditions as a result of changing levels of foreign production and demand in the developing countries
- Impacts of new technologies on consumption and production patterns and emissions

- Changes in the U.S. economy and energy system that could result from emissions taxes
- Effects of specific policies, such as mandatory appliance efficiency and building shell standards, on energy consumption
- Impacts of fuel-use restrictions (for example, oxygenated and reformulated gasoline or mandated use of alternative-fueled vehicles) on emissions, energy supply and prices, and economic growth
- Changes in natural gas prices and pipeline and import capacity in response to Federal and State regulatory initiatives
- Impacts on estimates of economically recoverable resources of crude oil and natural gas resulting from improvements in exploration and production technologies.

In the near future, a number of critical energy and economic issues are on the horizon. NEMS can be used to address such questions, including: energy security; efficiency improvements in energy production, conversion, and consumption technologies; regulatory reform in the natural gas and electricity sectors; and renewable energy. In addition, enhancements now being added to the system will provide the capability to examine important issues in the upcoming debates on policies to reduce carbon emissions in the United States.

Representations of Energy Market Interactions

NEMS is also designed to simulate the important interactions of energy markets. In the United States, energy markets are driven primarily by the fundamental economic interactions of supply and demand. Government regulations and polices can exert considerable influence, but the majority of decisions affecting fuel prices and consumption patterns, resource allocation, and energy technologies are made by private individuals or companies attempting to optimize their own economic interests.

The primary objective of NEMS is to represent the market behavior of the buyers and sellers of energy products and to determine how energy is used and produced at a level of detail that will be useful for analyzing the implications of government policy initiatives. The representation of energy markets in NEMS focuses on four important interrelationships:

- Interactions among the energy fuel supply, conversion, and consumption sectors
- Interactions between the domestic energy system and the domestic economy
- Interactions between the U.S. energy system and world energy markets
- Interactions between current production and consumption decisions and expectations about the future.

Energy Supply/Conversion/Demand Interaction

NEMS is designed as a modular system. Four end-use demand modules represent fuel consumption in residential, commercial, transportation, and industrial sectors, subject to delivered fuel prices, macroeconomic influences, and technology characteristics. The primary fuel supply and conversion modules compute the levels of domestic production, imports, transportation costs, and fuel prices that are needed to meet domestic and export demands for energy, subject to resource base characteristics, industry infrastructure and technology, and world market conditions. The modules interact to solve for the economic supply and demand balance for each fuel. Because of the modular design, each sector can be represented with the methodology and the level of detail, including regional detail, that is appropriate for that sector. The modularity also facilitates the analysis, maintenance, and testing of the component modules in the multi-user environment of NEMS development.

Domestic Energy System/Economy Interactions

The general level of economic activity, represented by gross domestic product, has traditionally been used an explanatory variable or "driver" for projections of energy consumption at the sectoral and regional levels. In turn, energy prices and other energy system activities influence economic growth and activity. NEMS captures this feedback between the domestic economy and the energy system. Thus, changes in energy prices affect the key macroeconomic variable, such as gross domestic product, disposal personal income, industrial output, housing starts, employment, and interest rates, that drive energy consumption and capacity expansion decisions.

Domestic/World Energy Market Interactions

World oil prices play a key role in domestic energy supply and demand decisionmaking, and oil price assumptions are the typical starting point for energy system projections. The level of oil production and consumption in the U.S. energy system also has a significant influence on world oil markets and prices. In NEMS, an international energy module represents world oil production and demand, as well as the interactions between the domestic and world oil markets, and calculates the average world oil price and the supply of crude oil and petroleum products. As a result, domestic and world oil market projections are internally consistent. Imports and exports of natural gas, electricity, and coal are represented in the individual fuel supply modules.

Economic Decisionmaking Over Time

The production and consumption of energy products today are influenced by past decisions to develop energy resources and acquire energy-using capital stock. Similarly, the production and consumption of energy in a future time period will be influenced by decisions made today and in the past. Current investment decisions depend on expectations about future markets. For example, the propensity to invest now to develop alternative energy sources is greater if higher energy prices are expected in the future. A variety of assumptions about planning horizons, the formation of expectations about the future, and the role of those expectations in economic decisionmaking can be applied within the individual NEMS modules.

Biofuels Representation in NEMS

Renewable Fuels Module

The renewable fuels module (RFM) consists of several submodules that represent the various types of renewable energy. Since most renewables (wind, solar, and geothermal) are used to generate electricity, the interaction with the electricity market module and its various submodules is important for modeling grid-connected renewable-electric applications. On the other hand,

many renewables are especially well suited for dispersed applications or generation at the point of end use. In the current version of the RFM, only grid-connected applications are modeled endogenously; data on dispersed applications are input exogenously. Biomass can also be used to produce liquid fuels such as ethyl alcohol (ethanol). Therefore, a primary NEMS interaction is with the petroleum market module, which determines refinery demand for ethanol as a gasoline blending component.

Each submodule of the RFM is solved independently of the rest. Interactions among the submodules occur indirectly through each submodule's interaction with other NEMS modules. Important inputs and outputs are shown below.

Important RFM Outputs	Important Inputs from NEMS	Important Exongenous Inputs
Energy production capacities Capital costs Operating costs (including wood supply prices for the wood submodule) Ethanol supply curves Load duration curves for solar-thermal, solar-photovoltaic, and wind	Installed energy production capacity Gross Domestic product Interest rates	Site-specific geothermal resource quality data Agricultural feedstock data (biofuels submodule) Site-specific wind resource quality data Plant utilization (capacity factor) Technology cost and performance parameters

Biofuels (Ethanol) Submodule

This submodule employs supply functions (cost vs. quantity) by PADD for ethanol produced from corn. Agricultural feedstock production quantities and costs are provided exogenously from a U.S. Department of Agriculture linear programming model, the Agricultural Resources Inter-regional Modeling System. The supply curves taken into account feedstock costs, feedstock conversion costs, and energy prices. The supply functions are used by the petroleum market module to compute regional demands for ethanol.

Biomass-Electric (Wood) Submodule

The wood submodule provides forecasted wood fuel prices and technology characterization information (capital costs, operating costs, capacity factors, etc.) for the EMM, thereby allowing wood-fired power plants to compete with other electric generating technologies. Wood fuel prices are represented by a supply curve constructed according to the accessibility of wood resources to the electricity generation sector. The supply curve employs wood resource inventory and cost data from the U.S. Forest Service, as well as wood distribution and preparation cost data. The supply schedule wood prices are combined with other variable operating costs associated with burning wood. The aggregate variable cost is then passed to the EMM.

Dispersed consumption of wood energy is modeled in the industrial, commercial, and residential demand modules.

Municipal Solid Waste Submodule

The municipal solid waste (MSW) submodule provides annual projections of energy produced from the incineration of MSW. It uses the quantity of MSW produced (derived from an econometric equation that uses gross domestic product as the principal forecast driver), the heating value of a pound of MSW, and shares of MSW combusted for energy recovery. The energy production forecasts are desegregated by consuming sector (commercial, industrial, and utility). In addition, the submodule supplies the EMM with capital and operating cost information, which is used only for calculations of electricity prices. (MSW energy production does not compete with other electric generating technologies, because MSW is viewed as a byproduct of a community's waste disposal activities rather than a competitive alternative to other fuels.)

International Energy Module

Oxygenates Supply Submodule

The oxygenates supply submodule calculates prices for MTBE and methanol oxygenate imports based on supply curves and import quantities estimated by the petroleum market module. Because of the potential expansion of the U.S. ethanol industry and the lack of commercial markets for other oxygenates, it is assumed that ethanol, ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), and tertiary butyl alcohol (TBA) are all supplied from domestic sources. Therefore, the IEM does not provide import supply curves for these oxygenates.

Transportation Demand Module

The Transportation Demand Module (TRAN) forecasts the consumption of transportation sector fuels by transportation mode, including the use of renewables and alternative fuels, subject to delivered prices of energy fuels and macroeconomic variables, including disposable personal income, gross domestic product, level of imports and exports, industrial output, new car and light truck sales, and population. Alternative-fuel shares are projected on the basis of a multinomial legit vehicle attribute model, subject to State and Federal government mandates. NEMS projections of future fuel prices influence the fuel efficiency, vehicle-miles traveled, and alternative-fuel vehicle market penetration for the current fleet of vehicles. Fleet vehicle characteristics and alternative fuel penetration can be set by the user to conduct an analysis of specific policy requirements.

Fuel Economy Submodule

This submodule projects new light-duty vehicle fuel efficiency by vehicle size class as a function of energy prices and income-related variables. In general, higher fuel prices lead to higher fuel efficiency estimates within each size class, a shift to a more fuel-efficient size class mix, and an increase in the rate at which alternative-fuel vehicles enter the marketplace. For purposes of policy analysis, the user can specify both fuel efficiency by size class and size class shares exogenously.

Regional Sales Submodule

This submodule is a simple accounting mechanism that uses exogenous estimates of new car and light truck sales and the results of the fuel economy submodule to produce estimates of regional sales and characteristics of light-duty vehicles, which are subsequently passed to the alternative-fuel vehicle and the light-duty vehicle stock submodules.

Alternative-Fuel Vehicle Submodule

This submodule projects the sales shares of alternative-fuel technologies as a function of time, technology attributes, costs, and fuel prices. Both conventional and new technology vehicles are considered. The alternative-fuel vehicle submodule receives regional new car and light truck sales by size class from the regional sales submodule.

The forecast of vehicle sales by technology requires a three-stage nested decision process. The first stage consists of endogenously calculating the sales shares between conventional and total alternative-fuel vehicles on a regional level, based on the following regional factors: fuel operating costs per mile (fuel price divided by fuel efficiency), vehicle price, range, emission levels, fuel availability, commercial availability, and regulatory constraints.

Once the level of total alternative-fuel vehicles per region has been calculated, the second stage estimates shares among the alternative-fuel vehicle technologies within each region, based on the same regional factors and methodology used in the prior step to calculate the shares of conventional and total alternative-fuel vehicle sales. Both the share between conventional and alternative-fuel sales and the share among the alternative-fuel vehicle technologies have a bimodal structure for either exogenously specifying the shares based on offline analysis or endogenously forecasting the shares. The third stage subdivides electric vehicle sales into individual electric vehicle technologies.

Important inputs and outputs for TAN are shown below.

Important TRAN Outputs	Important Inputs from NEMS	Important Exogenous Inputs
Energy product demand by mode Emissions Sales, stocks and characteristics of vehicle types by size class Vehicle-miles traveled Fuel efficiencies by technology type Alternative-fuel vehicle sales by technology type Light-duty commercial fleet vehicle characteristics	Energy product prices Gross domestic product Disposable personal income Industrial output New car and light truck sales Level of imports and exports	Current and projected demographics Existing vehicle stocks by vintage and fuel economy Vehicle survival rates New vehicle technologies and efficiencies, relative to conventional vehicles Vehicle prices, fuel availability, and commercial availability Vehicle safety and emissions regulations Vehicle miles-per-gallon degradation rates

TRAN includes the following alternative-fuel technologies:

Methanol flex-fueled
Methanol neat (85 percent methanol)
Ethanol flex-fueled
Ethanol neat (85 percent ethanol)
Compressed natural gas (CNG)
Liquefied petroleum gas (LPG)
Electric
Electric hybrid small internal combustion engine (ICE)
Electric hybrid 2-stroke engine
Electric hybrid turbine
Gas turbine gasoline
Gas turbine CNG
Gas turbine alcohol
Fuel cell methanol
Fuel cell liquid hydrogen

Light-Duty Vehicle Stock Submodule

This submodule specifies the inventory of light-duty vehicles from year to year. The survival rates and new vehicle sales of different vintages and classes can be set to reflect alternative policy scenarios that target specific vintages or size classes. The fleet of vehicles and their fuel

efficiency characteristics are important to the translation of transportation services demand into fuel demand.

The level of detail maintains 10 vintage classifications and 6 passenger car and 6 light truck size classes corresponding to U.S. Environmental Protection Agency interior volume classifications, as follows:

Cars:
- Min-compact - less than 85 cubic feet
- Subcompact - between 85 and 99 cubic feet
- Compact - between 100 and 109 cubic feet
- Mid-size - between 110 and 119 cubic feet
- Large - 120 or more cubic feet, including all station wagons (small, mid-size, and large)
- Two-seater - designed to seat two adults

Trucks:
- Passenger vans
- Cargo vans
- Small pickups - trucks with gross vehicle weight rating (GVWR) under 4,500 pounds
- Large pickups - trucks with GVWR 4,500 to 8,500 pounds
- Small utility
- Large utility

Vehicle-Miles Traveled Submodule

This submodule projects travel demand for automobiles and light trucks. The estimates are based on the fuel cost of driving, per capita disposable personal income, an index that reflects the aging of the population, and an adjustment for female-to-male driving ratios.

Light-Duty Vehicle Fleet Submodule

This submodule generates estimates of the stock of cars and trucks used in business, government, and utility fleets. It also estimates travel demand, fuel efficiency, and energy consumption for the fleet vehicles prior to their transition to the private sector at predetermined vintages.

Air Travel Demand Submodule

This submodule estimates the demand for both passenger and freight air travel. Historical data on passenger travel are desegregated between business and personal travel, while freight travel is desegregated by dedicated freight aircraft and air freight carried in the lower hull ("belly") of commercial passenger aircraft. In each of the four market segments, the demand for air travel is estimated through regression analysis as a function of the cost of air travel (including fuel costs) and economic growth.

Aircraft Fleet Efficiency Submodule

This submodule projects commercial aircraft stocks to provide estimates of average aircraft fuel efficiency (seat-miles per gallon) by size class as a function of jet fuel prices (which affect technology choices) and economic growth levels (which affect the age distribution of aircraft).

Freight Transport Submodule

This submodule translates NEMS estimates of industrial production into ton-miles traveled requirements for truck, rail, and ship travel, and further into fuel consumption by mode of freight travel. NEMS industrial production forecasts indicate value added by industry. Energy efficiency estimates of freight travel are structured to evaluate the potential of both technology trends and efficiency improvements related to energy prices.

Miscellaneous Energy Use Submodule

This submodule projects the use of energy in military operations, mass transit vehicles, recreational boats, and automotive lubricants, based on endogenous variables within NEMS (e.g., vehicle fuel efficiencies) and exogenous variables (e.g., the military budget).

Vehicle Emission Submodule

This submodule estimates the aggregate transportation sector emissions levels associated with the projections of vehicle fleet characteristics and transportation demand. Emissions estimates are made for sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon (C), and volatile organic compounds (VOCs). The emissions estimates are sensitive to fuel prices and efficiencies, vehicle travel, alternative fuels, new technology vehicles, and alternative ways of meeting transportation demand.

NEMS Biofuels Results

Transportation Demand

Alternative-fuel light-duty vehicle (LDV) sales represent:

- 2.1 percent of total LDV sales by 1995
  - 220,000 automobiles
  - 110,000 light trucks
- 9.0 percent by 2005
  - 1,070,000 automobiles
  - 400,000 light trucks
- 9.5 percent by 2010
  - 1,180,000 automobiles
  - 430,000 light trucks
  - 400,000 barrels per day of motor gasoline displaced
  - 6.6 million metric tons of carbon emissions reduction

Alternative-fuel light-duty vehicle (LDV) sales are driven by both legislative mandates and market demand. In 1995, all sales are legislatively driven. Of the 9.0 percent sales By 2005, 7.1 percent are legislatively driven, 1.9 percent market driven. Of the 9.5 percent sales By 2010, 7.3 percent are legislatively driven, 2.2 percent market driven.

Market driven sales are based in some fashion on the "Bunch Study", University of California Davis, survey of consumer preferences.

NEMS predicts the following alternative-fuel LDV technology sales distribution in 2010:

- CNG at 26.4%;
- LPG at 19.4%;
- Electric hybrid at 17.8%;
- Methanol flex at 13.0%;
- Dedicated electric at 12.2%;
- Ethanol flex at 8.6%;
- Ethanol neat at 0.9%;
- Methanol neat at 0.9%; and
- Turbine Hybrid at 0.07%.

APPENDIX C

A Biofuels Transportation Program Cost-Sharing Strategy: Building Success Today for Tomorrow's Expanding Biofuels Market

A Biofuels Transportation Program Cost-Sharing Strategy: Building Success Today for Tomorrow's Expanding Biofuels Market

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A Biofuels Transportation Program Cost-Sharing Strategy:

Building Success Today for Tomorrow's Expanding Biofuels Market

1.0 Biofuels Competitiveness and Program Successes

1.1 Introduction

This document develops a structure for an enhanced cost-sharing strategy for the Biofuels Transportation Program. A central feature of this strategy is the use of cost-sharing as a means to an end rather than as an end unto itself. Effective cost-sharing activities are targeted to accomplish specific program goals. The cost-sharing strategy recommended here goes beyond the practice of leveraging federal research dollars with other research funders. It is designed to expand the active program constituency, and enhance the focus of the program on near-term progress towards its Vision of bioenergy as an essential component of an environmentally sound and sustainable transportation system.

This report describes a cost-sharing strategy that builds on related program activities already in progress, and which can be expanded in scope today. It follows the Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program, submitted May 31, 1994, which discussed the biofuels transportation product line, four critical success factors, and the usefulness of the overall perspective of a corporate Product Manager. Cost-sharing is a vital tool of any Product Manager's product development plan, and is one which, in this case, directly supports the key success factors which have been previously identified.

The first section of this report establishes the basis for the proposed cost-sharing structure and strategy by reviewing the competitive market factors which place a premium on near-term activity and constituency building. The second section discusses the broadened characterization of cost-sharing which is adopted in this report to develop the strategy, and how that strategy is derived from the intersection of program needs and stakeholder's motivations. The final section

presents the resultant strategy elements and specific illustrative actions within its various categories which can be considered for early implementation.

1.2 Competition for the Alternative Fuels Market

Competition for the alternative fuels market is keen. The market is huge as are the required investments. The potential profits and concurrent risks are great, and the energy and environmental consequences momentous. However, this competition is not a winner-take-all contest. While petroleum-based transportation fuels and internal combustion engines (ICEs) have long dominated the transportation sector, future markets for transportation fuel and propulsion systems will be diversified. Alternative fuels and alternative fuel vehicles (AFVs) are mandated for introduction today, and will continue to gain market share. Just as the market is shared among automotive manufacturers today, so will market sharing exist in the future among the most viable fuel and end-use device systems.

This increased competition notwithstanding, petroleum-based fuels will continue to have a market presence well into the middle of the next century. Alternative fuels have taken initial market share through niches, and will grow by expanding those niches, improving their performance, further reducing their costs, and thereby developing new applications. For biofuels, the most promising market entry points appear to be located in regions where unique combinations of biomass supply economics, appropriate conversion technologies, and social objectives create opportunities for early acceptance. The use of industrial waste, in the form of biomass-based waste streams, combined with the creation of local jobs benefits, may offer the required economic competitive advantages for locally produced and consumed biofuels.

However, biofuels are currently at a competitive disadvantage with natural gas and electricity as alternative fuels; this is not a technical assessment, but a competitive assessment. Stakeholders for Electric Vehicles (EVs) and Compressed Natural Gas (CNG) vehicles have been more successful at promoting their products for public acceptance, gaining government funded demonstration projects and government mandated fleet purchases, and establishing cost-sharing activities. For example, the U.S. automobile industry participates in a multi-million dollar cost-

shared consortia to develop EVs and CNGs, and recently signed contracts with the Department of Energy (DOE) to develop fuel cell propulsion systems, but no such agreement exists for biofuels. The recent Environmental Protection Agency (EPA) decision on biomass-based fuel oxygenates, and proposed legislation to mandate ethanol content for fuels in non-attainment areas can assist in creating larger markets for biofuels. However, both of these actions are currently controversial rather than universally accepted. More needs to be done, if biofuels are to close the competitiveness gap that currently exists, before market dominant alternative fuel systems ultimately emerge.

1.3 The Program Product Line and Critical Success Factors

The Biofuels Transportation Program addresses a "product line" of diverse opportunity areas: ethanol, methanol, components for reformulated gasoline, biodiesel from aquatic species, and energy crops. Cross-technology comparisons of the marketplace for transportation fuels, however, focus on complete transportation systems and on those technology components that have potential for the greatest beneficial impact. When biofuels-based transportation is assessed in this systems context, there is one product with large beneficial impact, and which offers a unique portfolio of advantages in jobs, energy security, and environmental enhancement in near- and mid-term time frames -- ethanol. Therefore, we look upon ethanol fuel demand from renewable biomass as the product line leader, with adjunct product diversification associated with biodiesel and biomass-derived oxygenators for reformulated gasoline. The larger scale benefits from the product line leader justify the priority and budgets assigned to the program. The inclusion of adjunct products ensures that the broader potential of the complete product line is not overlooked.

The concept of critical success factors for the program originates in the need for a product manager to be able to obtain those resources (e.g., people, facilities, budgets) over time to complete the necessary technology development and diffusion processes and bring the product to market. The product manager also takes account of the state of the market and the likelihood of time constraints on market introduction, the shape of future budget profiles and the degree of assurance that funding will be provided over the duration of product development, barriers to

product entry into the marketplace, and the activities required to support successful commercialization and deployment.

Cost-sharing is a vital tool of any product manager's product development plan. Cost-sharing techniques can be synergistic with each of the four critical factors necessary for ultimate success in product development and marketplace introduction. A brief review of these critical success factors will provide the foundation for establishing the structure and strategic content of specific cost-sharing activities in furthering program goals.

Defining the Uniqueness of the Biofuels Transportation Product

Defining the unique value of renewable-biomass-derived ethanol as the product line leader, in comparison to other alternative fuels, is needed to attract investors and other partners to the program. Such a value does indeed exist in a total systems context, and provides unique benefits in both near- and longer-term time frames to serve as an integrative center of mass for the overall product line. Ethanol produced from fast growing renewable energy crops has the highest potential among comparable competing systems to simultaneously achieve significant reductions in greenhouse gas emissions in the transportation sector, displace oil imports, and maximize the growth of U.S. jobs in doing so.

Building an Informed Constituency

Clearly there is a need to build not only an informed constituency, but, further, a cadre of committed, enthusiastic stakeholders aligned by shared investment in a commercial biofuels products system. Potential stakeholders are involved not only in the development of ethanol as a product (researchers or corporations) but also as regulators, consumers, or environmental advocates. Once identified, stakeholders may be assessed for their potential as partners and how they can best contribute to the bioethanol development pathway. Sharing information, costs, risks and achievements are ways to build a committed constituency.

Emphasizing Concreteness, Credibility and Integration in the Program Design and Implementation

In order for biofuels transportation products to be delivered, a fully functioning biofuels support system with all of its related products and processes must eventually be brought into commercial operation. Today, different pieces of the biofuels products system are in place serving biofuels requirements. Some function under market conditions; others are subsidized by federal and state tax credits. Some products and systems needed to serve biofuels are in place but serve other products in the market. Niche market opportunities can help in the near term to establish functioning components of the support system so critical to demonstrating the concreteness and credibility of future system expansion. The program can effectively multiply its available resources and accelerate its outputs through carefully chosen cost-sharing partnerships. Because of the large number of related but disparate program elements, a special emphasis on integrating and focusing resources on niche market opportunities for its main products should prove to be particularly beneficial.

Near-Term Attention to Partnership and Timing

The race for the alternative fuels market is underway, with market introduction dates now projected for a variety of new fuels and transportation technologies. Partnerships which implement both direct and indirect cost-sharing provide a means not only to accelerate the product development and deployment process, but also to illustrate a broad-based visible involvement and commitment of key stakeholders. When the partnership is based on shared goals, cost, and risk, the achievements of each and every partner in this joint activity serve to the benefit of all.

2.0 Derivation and Structure of a Cost-Sharing Strategy

2.1 An Expanded View of Cost-Sharing

Cost-sharing is a key strategy to program success. First, it achieves the obvious - in its simplest form, it leverages R&D dollars for increased program impact. But cost-sharing is much more than R&D dollars, more than matching funds. Any stakeholder action that involves directing

non-program resources into biofuels development and deployment is an element of a cost-sharing strategy. These actions cover the range from conducting research, demonstrating biofuel technologies, preparing and distributing comparative energy analyses or market and benefit projections that tell the biofuels story in a favorable light, holding public information events, influencing other organizations' priorities and action plans, and building alliances, to investing in deployment, and creating the needed system infrastructure.

In short, a strategy built on this expanded view of cost-sharing involves the reallocation of program funds to facilitate a near-term emphasis on identifying and activating a visible program constituency, whose primary interests reside in the deployment phase as opposed to the development phase of biotransportation technology.

As used here, the concept of cost-sharing does not require a contractual relationship. Rather, it is a strategy for drawing forth the concerted effort of others. Of course, this can be accomplished through cost-shared R&D, cooperative agreements and CRADAs. It can, however, also be called forth by separately funded joint or synergistic activities, and by fully independent efforts that are beneficial overall to accomplishment of the program's established Vision.

From this standpoint, the dollar magnitude of constituency involvement is less significant than the widespread character and diversity of such involvement. Many such arrangements, involving modest program seed funding are viewed as preferable to only a few such arrangements in which significant program funds are committed to only a few entities. The latter approach is likely to be most desirable to achieve accelerated technical progress; the former approach is likely to be most effective in broadening the constituency base. Both objectives are valid program needs. We focus here on increasing involvement. This is proposed not for its own sake, but as a means of early engagement of those who can be brought to see a role for themselves in a downstream fully deployed system, or of those who particularly value the benefits which a fully deployed system can deliver.

Consider the competition among industries, researchers, government agencies, environmentalists, associations, and other stakeholders for control of the direction of the U.S. commercial alternative

fuels market. However, competition is not limited to just the alternative fuels themselves. Alternative fuel support systems (e.g., processing/conversion systems, delivery systems, feedstock supplies, propulsion devices, and other transportation technologies), each associated with a different alternative fuel, also contend for market position today. The competition among these alternative fuels support systems is currently more intensive than the competition among alternative fuels themselves. A cost-sharing strategy is critical to establishing support for, and maintaining investments in biofuels support systems.

Before alternative fuels displace significant market shares for gasoline and conventional ICEs, a clear view of how the supporting infrastructure that sustains the proposed alternative fuels being brought to market is a requirement. A cost-sharing strategy that attracts investments to biofuels support systems is essential to surviving in the competition as it is waged today. Market shares for alternative fuels in the future can be determined in large measure by decisions taken in the near-term which establish pathways and precedents that become increasingly difficult to overturn.

In the face of this competition, programs sometimes use the strategy of over-selling the impact and delivery of a product to keep financial support. For example, projected dates of a product's introduction into the market are accelerated, projected product prices are set to look competitive rather than true economics, R&D targets are established without a clear R&D pathway by which the goal can be met. While such a strategy may at times appear expedient, these episodes can also undermine a program's credibility. In no case is it wise to assume support will continue to be there simply because the product is a "better idea." A cost-sharing and constituency building strategy establishes the base of support, tests and refines the program story, and vitalizes market interest in maintaining the program in competition with other good ideas.

Because of feedstock specificity, there is a strong local and regional character to the program. While a top down approach may simplify the apparent main stream technical and economic development objectives, a parallel bottoms up component may more nearly capture the reality of deployment issues. Diversity in participation reaches out for new partners and new perspectives. It strengthens the program in its ability to transition from development to deployment.

In summary, the desired cost-sharing strategy seeks neither the leveraging of resources nor an expanded constituency for their own sakes. Both aspects may indeed be beneficial. However, what is really being sought here is increased program vitality, and the making of that vitality visible to others so that an accelerating accumulation of resources, skills and dedication can reduce market entry risks and, in turn, accelerate the delivery of program benefits.

2.2 Structuring a Cost-Sharing Strategy

The expanded cost-sharing strategy which we propose is most readily devised and structured by considering where and how the tactical objectives of the biofuels transportation program may intersect with the motivations of its stakeholders. Accordingly, we consider each of these two structural components in turn.

We address first a set of program tactical objectives. By definition, these are operating not at the high level of the program's Vision and Mission, but at a lower level of day-to-day engagement with issues involving stakeholder identification and activation.

Certainly one of the primary tactical desires is to engage potential downstream participants in the deployment process at the grass roots level. Strengthening the bottoms up program component increases the likelihood that technology development design and precommercialization efforts are maximizing awareness of niche market opportunities and the regional/local characteristics of future bioenergy systems.

Closely related is the tactical desire to identify and engage downstream players today, even if at only modest levels of current involvement. This tactical approach focuses, however, not only on grass roots participants but on other candidate elements as well. These might include very large companies, even nationally based entities, which see a future role for themselves, centralized voices of the environmental and renewable constituency, manufacturers of flexible fueled or dedicated ethanol fueled vehicles, designers and operators of regional conversion facilities, suppliers of harvesting equipment, and the like. Indeed, a review of the entire conceptual biofuels transportation system, from feedstock and conversion through distribution and

infrastructure and on to end-use, discloses a very large variety of participants and stakeholders of all sizes and character. In each instance it would be tactically desirable to have identified existing entities that are interested in visualizing themselves as contributing to the existence and operation of a biofuels industry.

Following this logic chain of tactical interests, there is a desire to show motion in the deployment process today. Since early entries likely depend on specialized situations (high value combinations of low- or no-cost feedstock, local/regional objectives, and niche markets), these situations need to be searched out, and efforts put forth to activate them. Broad inquiries of interest may be insufficient because of the general limited awareness of technology status and potential benefits. These opportunities may require substantial effort to seek out and for potential partners to become informed.

Still another tactical approach, which would also display deployment initiation today, is to seek an active exploration towards diversification into the renewable biotransportation arena by larger entities presently engaged in closely allied activities. Target examples are major suppliers to and producers of corn-based ethanol, large entities in the pulp and paper industry that use renewable biomass today for internal energy needs, holders of marginal crop lands not currently being exploited, and the like.

In all of these activities, and others that will subsequently be noted, there is a valid tactical objective to maximize program benefits by making productive use of other ongoing program activity with closely allied interests. For example, as biomass for electricity achieves successes in its area, it will inevitably be supporting the creation of active energy crop implantation, thus helping to further enhance the credibility of this component of the transportation system. The Clean Cities program may draw forth funding and activity from other entities which can benefit biotransportation objectives. The Climate Change Action Plan intensifies awareness of greenhouse gas issues. Independent studies by international organizations, environmental groups and others offer opportunities for the comparison effort of these other entities to assist the biotransportation program in achieving some of its independent objectives. States may fund regionally based activities to define local job opportunities. Other government agencies (EPA,

Agriculture) can contribute through actions funded in those agencies, but synergistic to biotransportation program needs.

Another set of tactical objectives relate to meeting information needs. These include finding enhanced mechanisms to inform and explain program Vision, Mission, pathways, and strategies. In addition to getting the story out, however, it is also desirable to find ways to minimize conflicts with potential competitors and self-serving critics. The third element of this multi-component information strategy is to seek to assure that the creators of third-party comparative analyses have the biotransportation component correctly understand and fairly presented. Given the tremendous volume and multiple sources of information available today, there is a final tactical objective to have a quick response capability in place so that there can be an effective dialog, when appropriate, with these multiple information sources.

In summary, the following tactical objectives have been considered:

- Active grass roots involvement
- Identification/activation of future participants today
- Visible entry of new players into niche markets
- Movement towards entry through diversification by larger entities
- Utilization of ongoing synergistic activities and organizations
- Strategic view of multiple information sources

All of these tactical objectives have the common characteristic of seeking to mobilize others and to multiply the power and effectiveness of program efforts through the actions of others.

The bases on which others can likely be motivated are well understood, and most of them require little discussion. A suggested list of motivating attributes is as follows:

- Jobs
- Profit derived from market-based participation in an expanding industry
- Environmental interests (e.g., in greenhouse gas reduction and cleaner air)

- Rural revitalization (feedstocks)
- Urban revitalization (end-use)
- U.S. economic security (reduced reliance on overseas oil supply, increased competitiveness in international markets)
- Foreign policy objectives
- Social and technological contributions
- Storytelling

The last three items may merit some explanation. Foreign policy objectives can come into play when the U.S. may be seeking one or more bases of active involvement with a specific nation. Technology collaboration in various areas has often been used for this purpose. One clear result is that the program, selected as a collaboration vehicle, may obtain a special level of additional support.

Social and technological contributors are those who become involved in a cause for the sake of supporting innovation and change, without regard to motivations other than personal satisfaction.

Storytellers are best exemplified by those elements of the commercial media which constantly seek new material to engage and retain their audiences. They have an active need to access new stories to tell.

Undoubtedly, other motivations or variations of these cited above could be adduced. However, the above list, combined with the earlier enumeration of program objectives, is adequate for the purpose of structuring their intersection and developing an expanded cost-sharing strategy. This is the topic of the following section.

3.0 Elements of the Proposed Strategy

3.1 Large-Scale Territories and Pathways

The biofuels transportation program can use an expanded cost-sharing strategy to motivate stakeholders to take actions that help to achieve program objectives. The principle point of using such a cost-sharing strategy is to maximize the effectiveness of program funds and the number and value of activities undertaken voluntarily by others that support program objectives. There are an unlimited number of activities that might be selected, but among them what collection of activities will comprise the most cost-effective strategy?

Activities need to be balanced so that progress is made as planned and the full diversity of program needs are satisfied. The power of the program objectives identified earlier is in their synergism and collective impact. Activities need to be balanced between those that engage stakeholders who are direct participants and those who are non-participants. Participant stakeholders are those who are or will be direct investors in the creation of the biofuels industry. Non-participants are those who lend support to the emergence of the industry because they value the anticipated benefits of that accomplishment. Keeping both groups of stakeholders engaged is important to an effective strategy. Lastly, there are trade-offs in the use of resources (people and dollars) that any given activity will consume in order to put into operation. Targeting those activities that will be the easiest and quickest ones to institute first will generate a near-term impact, while the more complex and time consuming activities are being developed. However, both near- and long-term targets need to be addressed simultaneously.

While many options exist for selecting cost-sharing activities, there are specific sectors, organizations and areas (i.e. territories) that are essential to be addressed as part of a cost-sharing strategy. Ten such territories are identified below. It may be less important which activities are undertaken in these territories than that each territory be addressed strategically and action programs be devised for each one.

1. Policy Umbrella Initiatives

Many policy initiatives target issues by bringing together a variety of interrelated topics under one policy umbrella. While transportation fuels may not be the direct focus of a given policy initiative, biofuel usage may be part of the solution. Two examples are DOE's Clean Cities program and President Clinton's Climate Change Action Plan. Thirteen U.S. cities now participate in DOE's Clean Cities program, and the list is expected to grow. The program supports formation of local government and industry partnerships to encourage conversion to fleet vehicles to alternative fuel use and the building of a fuel supply infrastructure. This program presents an opportunity to encourage maximum use of biofuels in each participating Clean City. The Climate Change Action Plan is a collection of actions, many of them voluntary, to reduce greenhouse gases. Current problems in funding the initiative may provide another opportunity to reconsider actions in the action plan that would help meet biotransportation goals. Other umbrella initiatives such as these exist both inside and outside of government where proactive program actions can create cost-sharing opportunities.

2. International Organizations

International organizations such as the International Energy Agency, the United Nations, and the World Energy Council engage in collaborative R&D, energy studies, information exchanges, and technology transfer activities. Active involvement in these organizations' energy and environmental activities can be used to influence their interests and products. These can include such outputs as favorable cross-technology analyses of the comparative benefits of biofuels. Technology transfer activities could be used to inform U.S. decision makers of the viability of biofuels by exposure to actual applications in other countries. Information exchanges can help identify potential biofuel technology, export markets, and gain technical knowledge by accessing the work of others abroad.

3. State and Local Governments

State and local governments have funds available to match federal funds. They also operate different programs which have tangible expenses. If a case can be made about the cost savings of biofuel initiatives that will have an impact on a state or local budget, real opportunities for cost-sharing exist. State and local elected officials will also see advantages to participating in high visibility programs that bring local benefits. For example, a robust biomass and biofuel industry would bring jobs and economic development benefits. New biomass industries could be especially attractive to rural economies with otherwise limited growth opportunity. Creating jobs, increasing tax bases, and adding infrastructure investments are tangible and highly desirable benefits to state and local governments.

4. Other Federal Agencies

Federal agencies such as the Department of Agriculture (DOA), Department of Transportation (DOT), Environmental Protection Agency (EPA), the Department of Commerce (DOC), the State Department, the Department of Defense's Advanced Research Program Agency (ARPA), and the Energy Information Agency (EIA) all have clear potential to provide synergistic support through their own budgets and activities to the needs of the biotransportation program. In addition to such opportunities in this territory, many existing capabilities exist which might be called upon directly, such as the use of Agriculture's extensive field communication structure to disseminate biofuels information to America's farmers. In addition, the Agency for International Development (AID) as well as DOC provide funds to promote energy technology exports. ARPAs "Technology Reinvestment Project" funds over 2000 projects, (although no projects for biofuels were funded in the first round). Working with these federal agencies to identify those activities that advance program objectives and cooperating to modify those activities to take account of biofuels issues could generate further opportunities to multiply the efforts by others.

In the case of EIA, their modelling and energy projection analyses tell a story about biofuels that has very high visibility and a cachet of objectivity. Working with EIA and similar energy policy analyses groups is a potential high pay-off area.

5. Bilateral Agreements

Direct agreements between the U.S. and other nations to cooperate on biofuels development can also be valuable. Public policy support for such agreements with nations where closer diplomatic relations are desired will accrue to biofuels development as well. Such agreements will help to open up potential export markets for biofuels technology from the U.S. Candidate bilateral partners deserving consideration also include Native American nation. Many reservations are seeking to develop self-contained economic enterprises that create new industries and jobs. The potential to create fully integrated biofuel production systems within a nation could be explored.

6. Large Companies with Diversification Potential

Bringing biofuels to market at competitive prices will require business investors and companies who believe they can make a profit in each of the components of the biofuels support system. Some of these companies will use equipment and technologies already used for other products. However, some of these companies will need to have current products and services modified in order to be responsive to the needs of biofuels production. These components include biomass production, harvesting equipment, storage facilities, treatment facilities, and conversion facilities.

Working with large companies who currently produce similar products is an effective way to cost-share. These companies know how to make a profit from producing certain goods. Seeking their participation to make a profit for producing similar products should be pursued vigorously. For example, Weyenhauser plants biomass, John Deere makes harvesting equipment, Seimans makes fermentation tanks, Gallo and Anheiser-Bush make fermented beverages: marginal investments and small modifications by these or hundreds of other large

firms is all that may be needed to make a profit in a future biofuels industry. Persuading large companies of the economic viability of a future biofuels industry and motivating them to invest in order to position themselves for this market is a critical territory.

7. Environmental Community

The claims for the environmental advantages of biofuels notwithstanding, negative environmental impacts are frequently associated with biofuels production. In addition to debate over the potential contribution to greenhouse gas reductions from biofuels production, environmental concerns associated with biomass production include soil erosion, soil productivity, chemical pollution, sediment loadings, soil capaction, wildlife habitat, and bio-diversity.

Working with environmental groups to communicate more effectively on environmental issues and reaching an agreed-upon vision as to how biomass production may be conducted under environmentally sound principles is vital. The principles and guidelines proposed by the National Biofuels Roundtable is one example. It may be useful to identify one specific environmental group which sees net environmental benefits from biofuels production and which would volunteer to act as a liaison and work with other environmental organizations towards the development of consensus views.

8. Regional Technical and Information Networks

In addition to working with individual states, regional technical networks provide valuable cost-sharing opportunities. Universities provide a primary source of expertise. Supporting a competition for the creation of regional centers of excellence is one means to generate cooperation among industry, government, and universities and create a prestigious community of biofuels technical expertise. The creation of these networks can also prove useful for providing information to regional decision makers. Regional networks that provide information on biofuels are another cost-sharing opportunity.

9. Biotransportation Association

An association with the mission to provide accurate, timely, "quick response" information on biofuels and to provide member services to the biofuels community is needed. Many associations addressing renewable issues currently exist. However, biofuels use for transportation has unique considerations that merit attention separately from other applications of renewable energy. Current associations have a mission focus that is either too broad or too narrow to meet the needs of an expanding industry in this area.

The formation of an Ethanol Institute as proposed by the Governor's Ethanol Coalition and NREL may be able to serve this role. One of the critical functions a biotransportation association should undertake is the capacity both to support the dissemination of objective information on biotransportation and to engage in dialog with program critics on a quick response basis. Such an organization if sponsored and staffed by industry, would be a true "cost-sharer."

10. Media

The importance of the breadth of information dissemination which takes place through the media is obvious. Since the media have communication channels to the public well established, they are a cost-sharing partner to tell the biofuels story. Increased public exposure to information that tells a story about the future viability of biofuels is clearly desirable. However, this is not a technical story, but a story about how consumers can benefit from the use of biofuels, about the actions necessary to create this industry, about the opportunities that exist to participate in the industry, and about action that can be taken to help bring it into being.

Each of these large-scale territories needs to be considered and strategic pathways for developing individual expanded cost-sharing activities within each of them need to be developed. In addition, however, there are also opportunities to multiply efforts in one territory through another. AID can assist with international organizations. Environmental

organizations can assist with the media. In the next section we seek to move from these territories down to more detailed strategies.

3.2 Candidate Cost-Sharing Activities

At a greater level of detail than "territories," many specific expanded cost-sharing activities could become part of the program's overall strategy. Candidate activities are listed below for consideration. The perceived attraction of any one of these candidate activities will vary by reader. The principle purpose of this list is to provide examples of the types of activities that have been used by other program areas and which may help to stimulate the development of still additional concepts for biotransportation.

Candidate activities are organized by the program objectives discussed in Section 2.1:

1. Grass Roots
2. Future Participants Today
3. New Players Into Niche Markets
4. Diversification Entry
5. Synergistic Activities
6. Information Strategy

Many activities can be seen to meet multiple objectives. Candidate activities were assigned to the objective they were most closely associated with. Explanations are not provided for activities where the rationale or opportunity is believed to be apparent.

1. GRASS ROOTS

- **Support the creation of an Interstate Biofuels Compact Commission (IBFCC).**

The Interstate Oil and Gas Compact Commission (IOGCC) is a state supported organization whose members are state energy agency executives. It provides a means for state energy representatives to publish studies and make recommendations on various topics. The IOGCC has been successful addressing key issues in an analytic and informed way, and has given oil and gas issues high visibility. An IBFCC could perform the same role for biofuel's advocates in the states.

- **Support the formation of jointly-funded Biofuels Centers of Excellence.**

Hold a solicitation to fund jointly with states five Biofuels Centers of Excellence. Submissions could be required to include one-third state funding, one-third university funding, and one-third industry support to be eligible for the "three-to-one" federal match.

- **Co-sponsor an annual competition for the fastest speed achieved and for the best miles per gallon in an alternative fueled vehicle (AFV) using biofuels.**
- **Support procurement of a Biofuels Exhibit that travels to worldwide meetings illustrating the viability of biofuels.**
- **Co-sponsor an AFV using biofuels at county fairs at Fourth of July parades to increase visibility.**
- **Create opportunities for the President and Vice President, State governors and City mayors to drive an AFV using biofuels.**
- **Create opportunities for corporate CEOs to drive an AFV using biofuels, and to purchase corporate fleets using biofuels.**
- **Cost-share with Rand McNally or State highway departments to support the development and dissemination of maps of the U.S., states, and metropolitan regions to show specific transportation routes which could be travelled using ethanol.**

- **Support the creation of interactive videos on ethanol as educational tools for different audiences (e.g., students, executives, financiers, government officials).**

- **Co-sponsor a nationwide lottery where 50 winners get a years worth of ethanol for free.**

- **Sponsor young scientist awards for the study of biofuels issues.**

- **Sponsor graduate assistantships at selected universities for research on biofuels issues.**

- **Work with DOE on the implementation of Titles III, IV, V, and VI, "Alternative Fuels and Electric Vehicles" regarding state alternative fuel and vehicle incentives planning.**

- **Plan for a major biofuels display on Earth Day including heavy media coverage.**

2. FUTURE PARTICIPANTS TODAY

- **Support an Ad Hoc Advisory Group to conduct a "technology scan" of other industries for technologies or technology sectors that may see business opportunities in a Biofuels industry.**

- **Support the formation of a Biofuels Research Institute modelled after the Electric Power Research Institute (EPRI) or the Gas Research Institute (GRI).**

- **Access information available in Europe about biofuel technologies through the International Energy Agency (IEA) Renewable Working Party and their Implementing Agreements.**

- **Convene leaders of the financial community (e.g., bank officers, mutual fund managers) to learn what indicators they look at in the alternative fuels market to make investment decision.**

- **Co-sponsor an annual conference on the "Biofuels Delivery System: One Step Closer."**

Breakout sessions could focus on each subsystem of the biofuels delivery system (e.g., production, harvesting, storage, preparation, conversion). Participants could draw from experts in fields where technology developments may have unforeseen applications to biofuels or foreseen business opportunities to private companies.

- **Support partnerships to co-locate biomass conversion plants with industrial production or power generation sites that give off heat as a waste stream in order to use this heat in biofuels preparation or conversion processes.**

- **Work with the White House and the Office of Management and Budget to ensure fair consideration of biofuels in fleet mandates through Executive Orders.**

- **Support pilot projects for co-locating biofuels conversion plants with industry or power generating plants to utilize complementary waste streams (e.g., heat).**

- **Work with State Advanced Technology Research programs to consider funding biofuels production technologies.**

- **Work with the Appalachian Regional Commission and Tennessee Valley Authority to fund economic development programs in biomass production and biofuel production technologies.**

- **Work with Department of Commerce and industry to co-sponsor a "technology mission" of automobile manufacturers and fuel suppliers to investigate the several thousand diesel vehicles run on pure biodiesel, primarily from rapeseed.**

3. NEW PLAYERS INTO NICHE MARKETS

- **Support pilot projects for use of municipal biomass waste (e.g., tree trimmings, mowed grass) for local ethanol conversion and use.**

  Biofuels conversion technologies able to use municipal waste could provide fuel cost advantages, have a reliable seasonal feedstock source and draw on the new funding source of local governments interested in creating markets for their biomass waste.

- **Co-sponsor regional biofuel production and utilization demonstration projects using different feedstocks.**

- **Support local partnerships with industries, labs, and local governments to conduct feasibility studies on the use of biomass waste and by-product from industry (e.g., food processing, beverages, lumbering, furniture manufacturing), local governments (e.g., grass mowings, tree trimmings), and landscape companies.**

4. DIVERSIFICATION ENTRY

- **Assist the corn-based ethanol community in examining how it could expand into other energy crops as demand for ethanol increases.**

- **Assist the domestic oil and refining industry in analyzing the national and corporate benefits of horizontal and vertical integration into biofuels.**

- **Assist the paper and pulp industry in analyzing the costs and benefits of becoming a supplier to the biofuels industry.**

5. SYNERGISTIC ACTIVITIES

- **Work with EIA to review modelling assumptions which impact projections of biofuel usage and the compatibility of those assumptions with BSD program assumptions.**

- **Develop a partnership with an organization that models the economic impact of biomass usage reflecting BSD program assumptions.**

- **Work with a renewables organization to develop a methodology for quantifying the energy security, environmental, and economic development benefits of ethanol market penetration on a regional and national basis.**

- **Work with a renewables organization to develop a methodology for quantifying the comparative net benefits of alternative ethanol R&D projects.**

- **Forge links with the Advanced Research Projects Agency (ARPA), National Science Foundation (NSF), U.S. Department of Agriculture, the Department of Transportation (DOT), EPA, and the Department of Defense (DOD) to fund research on biofuels issues.**

- **Work with DOE's Clean Cities Program to ensure that a percentage of AFVs and refueling stations use biofuels.**

- **Get actively involved in program agenda formulation of the White House Conference on Environmental Technologies.**

- **Get actively involved in the writing and review of the Administration's environmental technology strategy, led by the National Science and Technology Council.**

- **Support a Small Business Innovative Research program (SBIR) for biofuels technology development.**

6. INFORMATION STRATEGY

- **Support formation of a Biotransportation Association.**

- **Collaborate with industry and educational institutions to test and evaluate "near-term" biofuel-user vehicles and their associated infrastructure.**

This initiative could share the cost of purchasing, testing, and evaluating as many as 100 vehicles.

- **Sign a Memorandum of Understanding with DOD's Advanced Research Project Agency to coordinate RD&D with biofuel and transportation technologies.**
- **Work with DOA and universities to create a biomass planting cost software.**

Planting biomass has many economic uncertainties. The development of a spreadsheet-based model to help planters understand the economics of planting biomass in a given market will help farmers and investors understand the agronomics of these crops.

- **Co-fund a catalogue of purchasers of biomass, paid for by the biomass user industry.**
- **Work with the Chicago Mercantile Board of Trade to develop standards for quoting daily commodity prices for biomass.**
- **Get some commercial biomass farms into production.**
- **Work with DOA and universities to train their extension agents in the best practices for growing biomass crops.**
- **Team with states to create a jointly-funded pilot project for testing the capability of different biomass feedstocks with biofuel conversion technologies.**
- **Convene an Advisory Board of Mutual Fund managers who invest in renewable technologies.**

Such an Advisory Board could advise BSD on areas where investors have reservations about the technical feasibility and/or economic viability of some aspect of the biofuels support system.

- **Create a partnership with a renewables organization to promote export of biomass technologies developed through BSD support.**
- **Co-sponsor a series of regional educational meetings for industry held by local chambers of commerce on how to export BSD-supported products.**

- **Support market assessment studies to be conducted by an energy export organization for ethanol-related technologies in such countries and regions as Latin America the Newly Independent State (NIS), China, and the European Community (EC).**

- **Support publications to provide guidance on exporting to the ethanol industry.**

- **Co-sponsor conferences held in world regions (e.g., Latin America, Asia Pacific, NIS, Europe, Africa) on ethanol markets and opportunities.**

- **Work with AID to convene meetings of foreign energy and agriculture trade missions to meet with U.S. companies learn about biofuel technology export opportunities.**

- **Publish a "Notice of Program Interest" in the Federal Register on pilot programs for accelerating biofuels technology development.**

- **Convene an annual "Peer Review" conference to review R&D Pathways Methods, and Models.**

The Energy Information Administration (EIA) conducts a peer review conference at which industry and government experts critique EIA's modeling and assumptions. Such a biofuels R&D peer review conference, co-sponsored by Oak Ridge National Laboratory (ORNL) and the National Renewable Energy Laboratory (NREL), would not only improve the program's knowledge base - and thereby its program planning and timing - but would increase industry and association interest in the program.

- **Support creation of an International Biofuels Technology and Information Center by the International Energy Agency.**

- **Support publications that tell the successful biofuels story.**

- **Coordinate with the Biomass for Electricity community and identify areas of mutual interests.**

- **Become active with organizations who conduct cross-cut technology assessments.**

Methodology results can be used by renewables organizations to identify priority areas for policy issues. The results could also be used to communicate the priority development and deployment agenda to financial organizations which will be needed to help support financial investments in the industry.

APPENDIX D

Risk Management Pathways For The Biofuels Transportation Program

Risk Management Pathways For The Biofuels Transportation Program

DRAFT

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Risk Management Pathways
for the
Biofuels Transportation Program

1.0 Introduction

1.1 Purpose

This document proposes specific risk management pathways for the Biofuels Transportation Program, based on an independent assessment of important technical, economic and market risks inherent in the conduct of the program.

The material presented here incorporates and builds upon insights developed by Technology and Management Services, Inc. in two previous studies. The first, dated May 31, 1994, provided a "Preliminary Assessment of Critical Success Factors for the Biofuels Transportation Program." The second, dated July 29, 1994, discussed "A Biofuels Transportation Program Cost-Sharing Strategy: Building Success Today for Tomorrow's Expanding Biofuels Market."

In both of these prior studies, we have emphasized the importance of strategic program planning based on the concepts of a corporate Product Manager. In this view of the world, program success is associated with the anticipated deployment of technology and systems in commercial market places, delivering actual benefits to investors, suppliers and users. Critical program strategies are those which tend to increase the probability of the desired outcome. Risks are those factors which increase the difficulty of achieving success. Risk management pathways are specific critical program strategies intended to mitigate risks, and thereby enhance the likelihood of ultimate benefit delivery.

Extensive studies of the technology development and deployment process in the United States have been conducted by economists over the years. The work of Professor Edwin Mansfield is particularly useful in elucidating factors associated with successful programs.[1] (The

parenthetical references used throughout this report are keyed to a bibliography presented as Appendix A at the end of the report).

Mansfield identifies three critical events, each of which must be successfully and sequentially achieved, in order for investments in technology development and deployment to provide net public and private returns. These are:

- Technical success,
- Economic success, and
- Market success.

We assume a market-driven need. Obviously the proposed new system must be able to perform and functionally meet those needs. Typically, the demonstration of technical feasibility is the lowest cost phase of development. Furthermore, technical success, while a necessary condition for advancing towards commercial use, has little value in and of itself unless the subsequent conditions are met. Economic success is directed towards achieving conditions suitable for financial investment in system manufacture to proceed. Both entrepreneurial suppliers and their financing sources must be convinced that the technology can be created and distributed profitably at a price that provide a benefit to the user relative to other alternatives available in the market place. A technically feasible system that is never brought to market is not a programmatic success. Finally, however, the market entry process, once achieved, must also result in a market success in order to deliver the desired benefits. Market failures for new products are common events. Competitive factors, user preferences, degradation of costs or benefits under conditions of large-scale deployment, and many other elements can all lead to product withdrawal, or to a limited market size which cannot provide an adequate return on investment.

Thus, there are many ways for a technology development/deployment program to fail; and many factors must turn out very favorably in order for such a program to wind its way through a large variety of pitfalls to a successful conclusion. While the pathway to success may appear straight forward, simply a function of adequate time, resources and effort, the analysis of actual programs

places a very high premium on the identification and implementation of risk management pathways.

1.2 Background

In our prior preliminary assessment,[2] we chose the perspective of a corporate Product Manager assuming overall responsibility for the development and deployment of a product which was:

- Clearly and simply defined;
- Differentiated from other products by unique benefits;
- Appropriately priced, taking its benefits into account; and
- Reliably available, with an appropriate infrastructure for delivery and service.

Based on this approach, we defined the four primary critical success factors for the program as:

- Defining the uniqueness of the biofuels transportation product;
- Building an informed constituency;
- Emphasizing concreteness, credibility, and integration in the program design and implementation; and
- Near-term attention to partnership and timing.

The current program structure is quite complex in that it comprises (or must take into account) related elements across the entire fuel cycle which extends from biofuel production, harvesting, storage, distribution, pre-treatment, and conversion; to liquid transportation fuel product blending, distribution, and end-use device utilization; along with related issues of waste management, land use, and other environmental, health and safety impacts.

Our focus here is on closed loop (renewable) biomass. There are both annual and multi-year energy crop resources. Conversion techniques may involve anaerobic digestion or thermo-chemical approaches. Products may comprise neat ethanol or additives in the form of ethanol

(for gasohol) or oxygenated ethers (for reformulated gasoline). A further product involves biodiesel fuels made from still other renewable sources.

There is a single common thread that ties all of these diverse elements together:[2]

> "Ethanol produced from fast growing renewable energy crops has the highest potential among comparable competing systems to simultaneously achieve significant reduction in greenhouse gas emissions in the transportation sector and maximize the growth of U.S. jobs in doing so."

We further noted[3] that the biofuels Transportation Program can use an expanded cost-sharing strategy to motivate stakeholders to take actions that help to achieve program objectives. Target territories for action were identified as comprising:

- Policy umbrella initiatives,
- International organizations,
- State and local governments,
- Other Federal agencies,
- Bilateral agreements,
- Large companies with diversification potential,
- The Environmental community,
- Regional technical and information networks,
- A new Biotransportation Association, and
- Public information media.

Even with a heavily involved constituency, there are numerous requirements for simultaneous actions and infrastructure creation in order for the entire supply, conversion and use system to achieve operability. Each such requirement is a risk. A large enough set of such risks will ultimately generate a set of major barriers to program success. However, these risks can also be addressed with programmatic responses, just as the current technical challenges are being addressed, so as to enhance the likelihood of overall program success. This approach is the subject of the next section of this report.

2.0 Risk Management Pathways

2.1 The Dilemma of Expectations and Promises

When risk intensifies, credibility is a very important asset. However, credibility at the Product Director level can easily be eroded by promising too much too soon to the financial investors in the activity.

This is a significant dilemma. Investors demand both projections and commitments. Technology proponents are optimists by nature. Because technical feasibility is often the earliest issue, there is usually less peer-reviewed analysis of economic and market issues. It is tempting (and sometimes competitively necessary) to raise expectations. However, as time passes, experience accumulates and understandings deepen. Projections may have to be revised, and promises deferred. The resulting loss of credibility is a serious risk to the successful achievement of the sustained and increased funding needed to advance technology development and ultimately to sustain system deployment.

An explicit Risk Management Pathway is needed to deal with the multiple dilemmas posed by the obligatory nature of expectations and promises. Some important elements of the pathway include the following:

- Focus on benefit opportunities, as compared to guarantees;
- Emphasize the metrics of near-term progress, rather than the longer-term and less-certain future;
- Make extensive use of external peer review and feed-back mechanisms; and
- Bring industrial and investment community rigor into the development and establishment of time lines and cost estimates.

The avoidance of guarantees is one means of acknowledging the necessary existence of uncertainties and consequent risk in any lengthy development process. All estimates of the future are the result of manipulating specific input assumptions through specific processing

methodologies. These may be the best assumptions and methodologies available at the time. However, their future viability cannot be assured. Accordingly, rather than deal with outputs as future "facts," it is often a better strategy to emphasize how the outputs are developed from and dependent on the validity of the inputs and the processing methodology.

It is human nature, however, to want to test performance against predictions. This need can best be satisfied by focusing on near-term events which are more related to the application of skill and effort than they are to the vagaries of chance. Even in this case, conservatism is important. Five successes in a row will gain respect and support. Four successes and one failure runs the risk of the focus shifting to the single failure.

Program performers typically have difficulty in understanding the degree to which they are the captives of their own ideas. They may view assumptions as being conservative, whereas an external reviewer may perceive the identical assumptions as being optimistic. The focus here is not on which judgement is correct. Rather, the critical element is to ensure that the existence of a full range of expert opinion is known, acknowledged, and taken into account. For this reason a deliberate and intensive utilization of peer review and feed back mechanisms is often invaluable. Moreover, a peer review conducted by ones friends is not nearly so informative as one conducted by ones enemies. Contrary perspectives can be understood even though they are not agreed with. Improved understanding can support improved responses and reduce the risk of unexpected impacts.

The final topic is this set, schedules and cost estimates, is of sufficient important to warrant treatment in a stand-alone section which follows.

2.2 Schedules and Cost Estimates

Individual Product Managers are likely to believe that the evaluation schedule and cost estimation procedures on which they rely are reliable. However, long term studies of this technology development process across many different technology areas reveal that reliable estimates for first-of-a-kind events are the exception rather than the norm. It is essential to understand that

the problems and difficulties discussed in this section are common, wide-spread, and not unique to particular technology areas. As a result, the risks which they pose need to be taken seriously, and appropriate remedial actions taken as early in the development process as possible.

The original ground-breaking analyses in this area were done by the RAND Corporation for the Department of Energy (DOE) in the 1979-1981 time period.[4, 5] The work was precipitated by extensive overruns in project cost being encountered in the weapons programs of the time. Simultaneously, DOE noted cost overruns of more than 100 percent, schedule increases and performance shortfalls in energy plant projects involving oil shale, coal gasification, liquefaction, tar sands, solid waste management and nuclear fuel reprocessing plants. Literature searches then revealed similar experiences in other first-of-a-kind experiences involving water projects, other public works projects, and large private construction activities.

The Defense experience led to views that scope changes, the amount of technological advance being sought, and the length of development program were directly and consistently related to the magnitude of the estimation error. Based on these insights, RAND devised a statistical study of 40 pioneer process plants comprising 106 useable cost estimates. With this sample the misestimations were numerous and extreme. The resulting statistical analysis was able to explain and predict some 94 percent of the data points with a high degree of precision, based on a few key variables. The principle findings were that:

- Most of the cost estimation error can be explained by:
  - the deviation in technology from that embodied in prior facilities;
  - the detailed definition, or lack thereof, of site-specific considerations; and
  - process complexity.
- Most of the performance shortfall (and thus the related facility operating cost) error can be explained by:
  - the degree of new technology embodied in the facility; and
  - whether or not solid material is present in process streams.

Biofuels plans are expected to be piloted at small scale and then extrapolated to commercial scale facilities. Even if individual process elements (unit operations) are "well understood," the overall system easily meets all the typical characteristics of the pioneer plants considered in the RAND studies. In addition, solid matter (the energy crop being digested or otherwise converted) will be present in process streams,. Accordingly, difficulties in cost estimation should be expected.

Similar difficulties should be expected in connection with estimating the cost of production, harvesting and distribution of the energy crops themselves, since these are likely to be first-of-a-kind experiences at the scale envisioned. Furthermore, energy crops will incur cost and output risks associated with resistance to emerging pests, the introduction of new type of harvesting equipment, the requirements of specialized pretreatment prior to processing, and many other unknowns.

Another risk area in the development of schedule and cost estimates for new technology is the fact that such estimates are usually done in early stages of technology advancement by technologists rater than by experienced design and construction engineers. Furthermore, estimates developed at a cost of a few tens or hundreds of thousands of dollars by simplistic techniques (counting tanks, ratioing from analogous types of facilities) have been shown to be potentially highly unreliable. In the world of electric power generation technology, the Electric Power Research Institute may commit to a one million dollar level of detailed facility design, conducted by a commercial architect-engineering company, in order to achieve acceptable levels of confidence regarding the competitive economic status of an emerging technology.

There is substantial evidence that cost estimates based on less extensive design (site and facility) information and less detailed cost data require a much higher level of contingency in order to avoid underestimation. Typical industry standards[6] are as follows:

Estimate Class	Class Description	Recommended Project Contingency (%)
1	Simplified	30-50
2	Preliminary	15-30
3	Detailed	10-20
4	Finalized	5-10

Each of the above classes is defined in terms of required design basis and cost detail. For example, a Class 3 estimate requires a complete process design, an engineering design that is 20 to 40 percent complete, a definitive project construction schedule, firm price quotations for major equipment, detailed quantity takeoff (from engineering drawings) on other materials, inclusion of taxes and freight, and other requirements. Unless this detail is available, a contingency level of up to 30 percent may be required to assure a reasonable validity for the estimate.

While the introduction of real-world conservatism (based on experience) tends to increase programmatic estimates of cost at the time of market entry, there are compensating factors (again based on experience) which provide beneficial offsets soon thereafter. There are economies of scale which can be achieved as the initial market expands, as well as learning curve effects which reduce cost in accordance with the cumulative amounts of product produced.

The distinction between initial market entry costs (high) and mature technology cost (much lower) is an important one. It needs to be planned for and accommodated as part of the market entry strategy. Recognition of this distinction can enhance credibility, whereas a strategy which does not take it into account can lead to disillusionment. For this reason, a key Risk Management Pathway is to plan for market entry in niche applications (which can accept high cost in specialized circumstances) and market growth through diffusion outward from niche entry points. This is the subject matter of the next section.

2.3 Connecting Development to Deployment

Market performance in terms of product sales is typically described over time by growth curves which are somewhat S-shaped in nature.[7] Following entry, a period of initial slow growth

translates exponentially into a period of rapid growth. As the market becomes saturated, growth tapers off again, and sales approach an asymptote characteristic of the market size. Assuming that each unit sold generates a stream of benefits, and that both costs and benefits are corrected for the time value of money, then this growth curve becomes a key descriptor of program benefits.

Mathematically, each such growth curve can be characterized by three data points:

- Date of market entry,
- Time required to reach a specified percentage of market saturation, and
- Magnitude of the asymptote associated with 100 percent saturation.

Each of the above parameters is directly able to be attacked by research and development activity in the development (pre-deployment) phase of the program.

Delayed entry risks both the possibility of being overtaken by competing concepts (or otherwise losing a window of opportunity) as well as the loss associated with a lesser value of money following discounting from the later date. Accordingly, early entry is worth an additional investment to achieve it, and this investment can in fact be recovered by advancing the entire set of benefit streams which it initiates.

Furthermore, if early entry is directed at a niche market opportunity, the subsequent cost reduction arising from additional development, technology maturation and learning curves can expand the market so that the growth curve simultaneously expands by diffusion towards a higher level of asymptote, and rises more rapidly along its slope because of the more attractive price/cost differential. Each change (entry date, slope, and asymptote) from what otherwise would have existed as a reference market introduction case can reduce risks and increase benefits. Hence, development expenditures that attack these targets can be cost effective.

Therefore we designate a development strategy which analyzes economic and performance needs backwards from technology deployment scenarios, and uses this information to redesign development targets, as a key Risk Management Pathway.

This type of analysis also forces attention on the interaction of complete systems. In this context, the relationship between ethanol cost and value is a key determinant of market entry date, growth rate and market niche (asymptote). The last 20 percent reduction in the desired cost of production of ethanol may be quite difficult to achieve. However, in a systems context, one can observe that for mid-grade fuel in 2010, the value of ethanol may be 20 percent higher in an optimized engine than in a standard engine.[8] As a result, it may be cost beneficial (and good risk management practice) to place the emphasis on engine optimization as the means to achieve the last increment of the desired targeted cost-value relationship.

A third aspect of connecting development to deployment is associated with early involvement of suppliers and users, including regional stakeholders. The funding of numerous separate regional centers ensures both that program knowledge is widely distributed, and also increases the likelihood that one or more centers will serve as the focal point for a market entry event.

Large scale experience in energy crop plantation management, for multiple crops in diverse locations will likely be necessary to achieve technological credibility (cost, yield and performance), as well as to assure the ability to obtain standard commercial financing for market expansion ventures.

Multiple regional presences will also aid in identifying future energy crop plantation sites as well as the current agricultural or forestry residues that may support niche market entry where use of such feedstocks may bring a cost credit to the enterprise (as a result of avoided disposal costs). The pursuit of such special market entry opportunities is an important Risk Management Pathway.

The fourth element of connecting development to deployment as a means of reducing programmatic risk is the aggressive pursuit of "cost sharing" (any stakeholder action that involves

directing non-program resources into biofuels development). This topic was discussed at length in an earlier report[3] and is mentioned here again only for completeness.

By definition, stakeholders have a down-stream interest in the results of program activity. The prospects and characteristics of deployment motivate their current roles and degree of involvement. Risk reduction is associated with increasing the size and the participation of an active constituency.

In summary, the elements of a Risk Management Pathway associated with connecting development to deployment include:

- Working backwards from an analysis of market entry and growth scenarios in order to define key development targets which will impact entry date, growth rate, and ultimate market size;
- An emphasis on cost and performance tradeoffs that may exist across complete systems;
- Intensive regionalization; and
- Aggressive pursuit of "cost-sharing," whereby interest in potential future deployment outcomes is translated into near-term contributions to development needs.

2.4 Completeness

The next set of related topics are collected under the Risk Management Pathway heading of Completeness. Strategic elements of the pathway include the following:

- Complete integration of closely related program elements, and the avoidance of transitional "gaps;"
- Early involvement and vertical integration of major players for the long term; and
- Explicit and early attention on infrastructure design and creation.

Each of the above elements is directed at minimizing risks associated with the simultaneous interdependence of many different elements which must all develop in concert with each other to achieve a viable overall system.

In the world of commercial research and development, there is increased emphasis on the use of multi-disciplinary product development teams. Fragmentation of developmental responsibilities into separated groups of experts for subsequent assembly by others simply tends to ensure mismatches at the interfaces.

Because many discrete steps are required through the extent of the biofuels fuel cycle, it is particularly important to assure potential investors at each step that interface problems or unexpected gaps of capability will not occur at the various key transitional points.

If the energy crop cannot be economically harvested, stored and distributed, it does not matter that it was successfully grown at the estimated cost. This risk can be a major deterrent to a potential investor. A belief that harvesting equipment designed and used for other purposes can readily be adapted to a different application may prove to be a valid assumption. Technology development/deployment experience, however, is full of counter examples whereby assumptions that appeared to be straight forward failed to perceive the existence of cost and performance barriers.

A similar risk is associated with requirements for specialized pre-treatment prior to crop conversion. Experience with coal-based fuels have shown that an extremely wide range of reactivity, conversion performance, and waste management issues are attached to specific varieties of feedstocks. Similar performance ranges, with important cost consequences, should be anticipated for solid renewable feedstocks.

Demonstrations of continuous flow across all the elements of the fuel cycle are highly desirable. Care and thought also need to be given to the question of scale at which such demonstrations are conducted. Cost increases with scale, but so does confidence.

Still another means to facilitate integration of both development and technology flow is to seek the early involvement of major players who have an interest in vertical integration. Such players must typically be large in size because the investment in sequentially-connected, multiple-process steps, which is characteristic of vertical integration, requires substantial financial resources. Nevertheless, it becomes a much simpler task to analyze interfaces when the tasks on both sides are expected to be performed under the direction of a single management. Furthermore, if the crop producer and the conversion facility operator are the same entity, then the crop producer knows the market for his product, and the convertor knows the source of feedstock for his operation. This leads to both reduced technical risks and reduced investment risks.

With respect to infrastructure design and creation, risk reduction strategies are more difficult to identify and implement. They should certainly include a major effort on the establishment of standards. Industry committees on infrastructure needs are being supported under the electric vehicle program. Such groups help to clarify which requirements industry believes can be pursued without government assistance, and where priority government involvement in infrastructure issues is important, and why.

There can also be important opportunities to reduce infrastructure risks through participation in "umbrella" type programs such as Clean Cities or The Presidents Climate Change Action Plan. Such programs rely on interaction with the private sector, and tend to focus on delivered benefits. Hence, infrastructure needs are inherently identifiable in the structure of their actions.

Fleet applications are also an available concept to demonstrate the operation of alternative fuel transportation systems. In a commercial setting, and at a sufficiently large scale, considerable experience can be gained in a reasonable time period to test the completeness of the system under a wide range of conditions.

2.5 Educating Stakeholders About Environmental Externalities

The unique capability offered by the Biofuels Transportation Program is the reduction in net greenhouse gas emissions, along with its transition from dependency on foreign oil imports to

reliance on domestic jobs for indigenous energy production. Other benefits, such as revitalization of rural communities, are also foreseen. Most of these benefits are not reflected in market prices. Accordingly, the normal forces which bring a new product into the marketplace (a better product at a lower price) are intially absent.

Either conventional products must become more expensive (penalized for their adverse impacts), or biofuels must receive sufficient subsidies to achieve enough market position to exploit learning curves for cost reduction and eventual unsubsidized price competition.

Both of these pathways are public policy issues with proponents and opponents. However, those who understand the issues are in the minority, and a public consensus to change the status quo in any way would appear to require a much more informed general public than presently exists.

Any action to translate the perceived costs of environmental externalities into market signals will significantly reduce investor risks and enhance the likelihood of program success. Accordingly a major action program to analyze such externalities constitutes an important additional Risk Management Pathway.

The most credible valuation of externalities is through the concept of avoided costs, namely the cost of actions that would otherwise have to be taken to manage or reduce the level of the externality. However, it is still difficult to translate this concept into specific costs, since it is marginal expenditures (not average expenditures) that are avoided. Presumably these are also the most costly expenditures. Avoided costs may often be regional and otherwise case-specific. As a result, the application of avoided cost methodology is still more of an art than a science. Nevertheless, increasing public knowledge of the importance and value of avoided externalities can result in public action to change market economics and make investments in biofuels and renewable technology development and deployment much more attractive.

Appendix A

Bibliography

Risk Management Pathways

For The

Biofuels Transportation Program

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APPENDIX E

IEA Bioenergy Agreement: Assessment and Strategy Documents

Observation on the IEA Bioenergy Agreement

1. **Relationships with Other IEA Entities.** The documents is silent on relations with other parts of the IEA operations. Some items to consider include:

   - Making the BA useful to its parent working party on renewable energy (REWP). Who is U.S. representative on that body? Obtain guidance and objectives from REWP, or, better yet, suggest to them what targets they might lay on the BA.

   - Considering possible synergism with the Working Party on End-Use Technologies. This group has an Annex on Alternative Motor Fuels.

   - Noting Ministerial Objectives of the IEA itself. These include greater involvement with non-member countries.

   - Connecting to IEA data programs.

2. **Industry Involvement to Enhance Near-Term Relevance.** Perhaps there should be an explicit objective to enhance industry involvement in BA activities. This could include not only participation in the annexes (financially and technically as a co-funding partner?) but also invited guest presentations by industry at BA Executive Committee meetings, industry review of BA work plans, etc.

3. **Strategy to Broaden Membership.** This is discussed on page 14 of the document in two paragraphs. This is a very brief treatment for such an important subject. Consideration might be given to interaction with other international energy organizations (e.g, OLADE in South America with Brazil as a member, or the World Energy Council, also with Brazil and Russia as members) as one way to access interesting countries on other than a country by country basis. The WEC has a U.S. arm, the U.S. Energy Association, as well as similar local organizations in each member country.

4. **Relevant U.S. Activity in Biomass and MSW to Electricity.** See the attached documents on activities by EPRI on Whole Tree Energy and Ogden on MSW.

5. **Why Biofuels?** The opening material has relatively little impact because of its focus on the distant future (100 years from now). Biofuels may be providing much more than 7% of world energy today, if proper account is taken of non-commercial fuel use. Some estimates have placed biomass use today at 15% of primary energy. Biofuels are used and under development because of actual or potential value associated with:

   - Indigenous fuels, a local/regional resource which helps reserve hard currency for economic development, provides domestic jobs and contributes to energy security.

   - Environmentally superior.

- Less costly than alternatives, and a competitive force to help restrain increases in the costs of other energy sources.

The BA might develop improved quantification and descriptions of

- Where, how, and to what extent biofuels are in use today,
- Why and how these applications arose, and
- Benefits being provided by the applications.

All of this would be directed towards a better near-term application of the role and value of biofuels.

6. **System Studies and R&D Relevance.** The Systems Studies are currently only one component of BA R&D Annexes. Such systems work at the international level probably has more potential to raise R&D budgets back home for all participating countries than any other BA activity. In addition the Executive Committee could take the view that systems work could help prioritize and focus the R&D activities by identifying specific needs, questions to be answered, data to be obtained, etc. These views would support giving systems studies greater prominence in the BA Annex Package, and more strategic discussion in the document on the near-term subject matter of such studies. The BA would then also take some cognizance of how biofuels fared in the recent IEA publication on Cars and Climate Change.

7. **Fuels or Fuel Utilization?** Page 20 of the BA says that the future task in biomass utilization will focus on biomass to electric power and biomass to liquid fuels. Electric power is a uniform product if produced inside a large system; however, bioliquids differ from other fuel liquids with which they compete. Important differences may exist in transportation, distribution, emissions on combustion, etc. Hence, the second category cannot address utilization unless it goes beyond fuel production. One possible formulation would be biomass to electric energy and biomass to transportation energy.

8. **Barriers.** Pages 5 and 6 of the BA flag the importance of addressing barriers to increased biofuels utilization. However, this very important theme does not appear to be implemented in what follows later in the document. Under objectives on page 6, the concept of overcoming barriers is not even given separate prominence, currently appearing as only one of three thoughts inside one of three bullets.

9. **Benefits.** The statement of benefits on page 7 is weak. Most focus is placed on information exchange and networking which are code words for personal travel abroad. Perhaps the BA should place more emphasis on building in and identifying very specific significant benefits as an aid to increasing both non-member participation and future year budgets.

10. **Financial Institutions.** Financing is key, particularly in developing countries. What are the positions of the World Bank and the various Regional Development Banks on biofuels projects?

IEA Biofuels Agreement
Possible Revised Structure

Introduction

- Document purpose and audience
- Topics, and the order in which they are presented

Importance of Biomass Collaboration

- Biomass potential to meet IEA shared goals
- Current situation
- Forces of change
- Barriers

BA Objectives and Strategies

- Objectives and Role
- Strategies, including diversification and broadening of involvement
- Possible new directions and options

Procedural/Organizational

- Organizational location and internal structure
- Tasks 95-97 (see Appendix) and resources implied
- Participation guidelines
- Initiatives and other procedural material, including relation to other IEA activities

Appendices

- Tasks
- Other information not critical to include in main body text

Review of Draft Strategy Plan
IEA Bioenergy Agreement

This review summarizes the subject matter of the draft Strategy Plan, notes comments received on it from IEA reviewers, and suggests a response to those comments. It concludes with a proposed outline for a shorter document, based on comments received.

I. INTRODUCTION

This section presents information on world bioenergy demand and use. It defines bioenergy, and discusses the drivers for market expansion.

IEA Comments: Too long and detailed. Delete section on current energy contribution. Emphasize a few key points.

TMS Comments: Section is needed here on: "Why is biomass an important collaboration area for the IEA?" Should also address how activity under Biofuels Agreement meets the IEA "shared goals." Suggest a much shorter section with 3 elements:

- Current situation
- Forces of change
- Potential to meet IEA goals.

While this does not appear very different from the present material in outline, the presentation could be more highly focussed, shorter, and be written to support a finding that biomass collaboration needs to be an important IEA activity.

II. BARRIERS

IEA Comments: No adverse comments. Add material on strategy options.

TMS Comments: Agree. This section is the other half of Section I. Together, they

establish a basis and direction for biofuels collaboration through their selection of topics.

III. ROLE OF IEA/BA

IEA Comments: No comments.

TMS Comments: The first half of this section is organizational and implementation material which can be deferred to later. The second half presents an IEA biofuels mission. Page 6 is much too late in the document for this strategic statement. It needs to be presented earlier and integrated with Sections I and II above.

IV. OBJECTIVES

IEA Comments: No comments.

TMS Comments: This material ties directly to the barriers discussion and should not be separated from it.

V. BENEFITS

IEA Comments: No comments.

TMS Comments: Part of IEA organizational information. No specific biofuels orientation given. Could be connected to other organizational, procedural information.

VI. NATIONAL R&D PROGRAMS

IEA Comments: Delete examples.

TMS Comments: Agree. The main statement is an important view of strategic policy for diversity in the R&D portfolio. This thought could appear much earlier as one of the elements of strategy what is currently Section II (where the IEA comments suggested strategy options be added).

VII. ORGANIZATIONAL STRUCTURE

IEA Comments: Shorter and rewrite. A separate IEA reviewer has assembled key information to be presented here. Add '95 & '97 focus. Add information on cooperation with other IEA units and activities.

TMS Comments: Agree. Suggest materials now in III be brought down to this section.

VIII. RESOURCE REQUIREMENTS

IEA Comments: Some editorial changes. Add a reference to Task Descriptions in Appendix.

TMS Comments: Not a stand-alone section. The information could be presented in a single sentence as a part of VII above.

IX. REVIEW AND EVALUATION

IEA Comments: Some deletions.

TMS Comments: This section primarily cites internal IEA procedures which are documented elsewhere. It could be incorporated by reference (or summarized in a single paragraph in Section VII above).

X. PUBLICATIONS

IEA Comments: No comments.

TMS Comments: Same comments as under Section IX above.

XI. STRATEGY TO BROADEN MEMBERSHIP

IEA Comments: No comments.

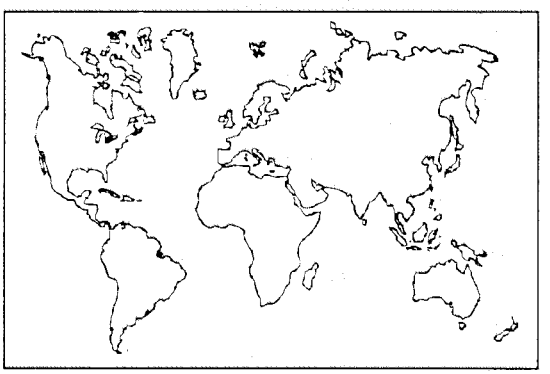
TMS Comments: This is a key strategy element and should appear as part of what is now Section II.

XII. APPENDIX

IEA Comments: Use 3 tables.

TMS Comments: Tables are feasible approach and would probably make material easier to read and compare. Key strategic elements of tables could be brought up into the main document.

IEA BIOENERGY AGREEMENT



STRATEGIC PLAN

AUGUST 1994

IEA BIOENERGY AGREEMENT
STRATEGIC PLAN

Table of Contents

IEA BIOENERGY AGREEMENT
STRATEGIC PLAN

I. INTRODUCTION

The International Energy Agency (IEA), founded in 1974 as the energy forum for 23 industrialised nations, is at the forefront of world efforts to advance the development and deployment of sustainable energy technologies. As one element of this effort, the IEA Committee on Energy Research and Technology (CERT), through its Renewable Energy Working Party, has established a collaborative Implementing Agreement on Bioenergy (see the detailed organisation chart at Figure 5 in Section V).

This Bioenergy Agreement Strategic Plan summarises the joint views of the multinational participants (currently 15 countries and the European Union) who collaborate as members of the IEA Bioenergy Executive Committee. In doing so, it also seeks to motivate the participation of industry and other interested nations, as well as broaden public awareness and support for its activities.

This document is divided into four additional sections and two appendices. The Vision and Mission of the collaborative activity being conducted under the Bioenergy Agreement are presented in Section II. The importance of this collaboration is discussed briefly in Section III, with particular emphasis given to:

- The potential of widespread commercial application of biomass energy to assist participating nations in meeting the Shared Goals of IEA member countries
- The evolutionary forces that support the enhanced use of bioenergy for sustainable development
- The difficulties and barriers which must be addressed to help make this vision a reality.

These benefits and needs support the identification of specific, near-term Objectives and Strategies for the Bioenergy Agreement, which are presented in Section IV. The selected time

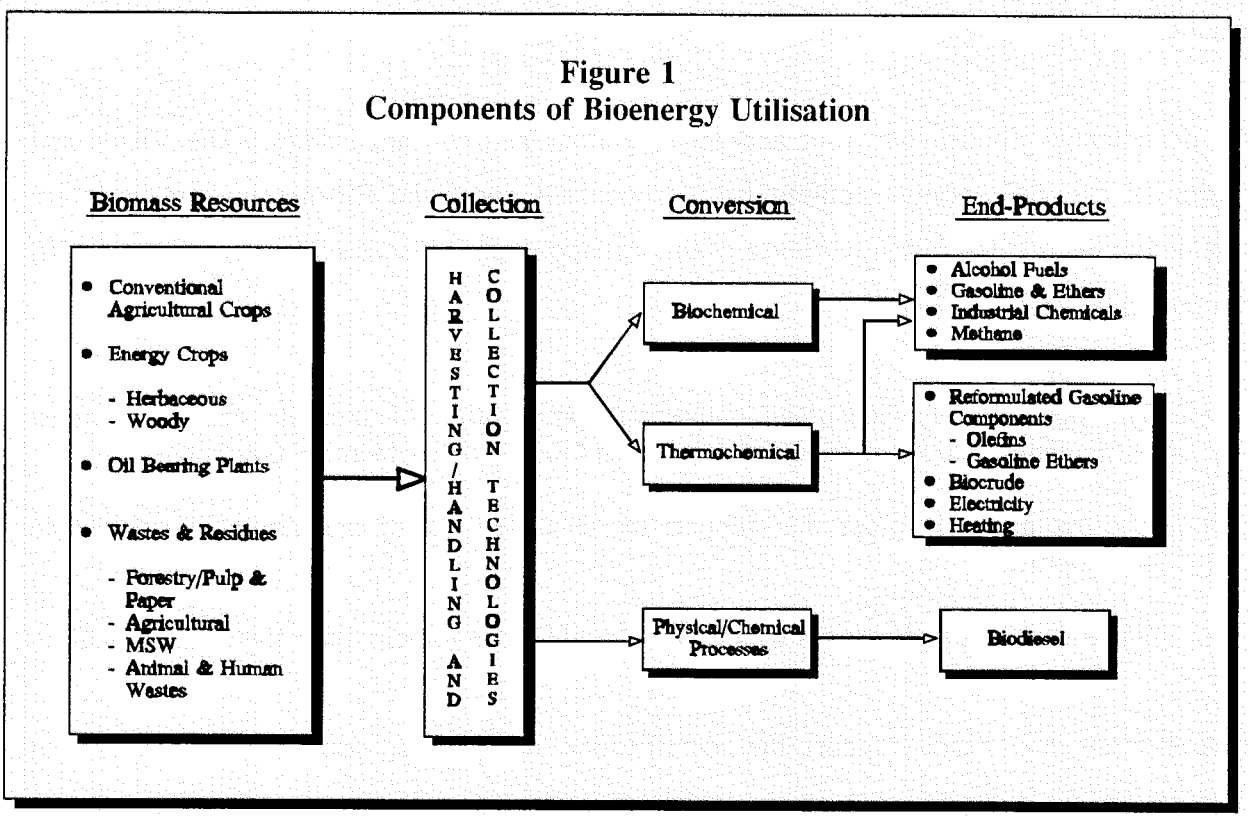
focus is the approved three-year programme period of 1995 through 1997, with some consideration of needs beyond that period as necessary and appropriate. The Objectives and Strategies are the central elements of this Strategic Plan because they are intended to guide and help prioritise collaborative activity during this programme period.

Important organisational and procedural information is presented in the final section (Section V) of the document, both for ready reference and for the benefit of potential new participants. Details of the proposed collaborative task activities as well as the IEA-prescribed task review and evaluation process, are included as Appendices.

II. BIOENERGY VISION AND MISSION

Bioenergy is the production and conversion of material produced by photosynthesis (including organic waste) to manufacture fuels and substitutes for petrochemical and other energy intensive products. Figure 1 depicts a host of biomass resources, collection procedures, conversion technologies and end products associated with bioenergy utilisation.

Figure 1
Components of Bioenergy Utilisation



Our Vision of bioenergy utilisation for sustainable development is as follows:

VISION

TO REALISE THE USE OF ENVIRONMENTALLY-SOUND, COST-COMPETITIVE BIOENERGY ON A WORLD-WIDE, SUSTAINABLE SCALE.

This Vision will be pursued over the 1995 to 1997 period (and beyond, as may be agreed) through conduct of the following Programme Mission.

MISSION

TO MAINTAIN, COORDINATE, AND FACILITATE BIOENERGY RESEARCH AND DEVELOPMENT THROUGH INTERNATIONAL CO-OPERATION AND INFORMATION EXCHANGE, LEADING TO THE OPEN-MARKET ADOPTION AND COMMERCIALISATION OF THE MOST EFFICIENT AND COST-COMPETITIVE BIOENERGY TECHNOLOGIES.

III. IMPORTANCE OF BIOENERGY COLLABORATION

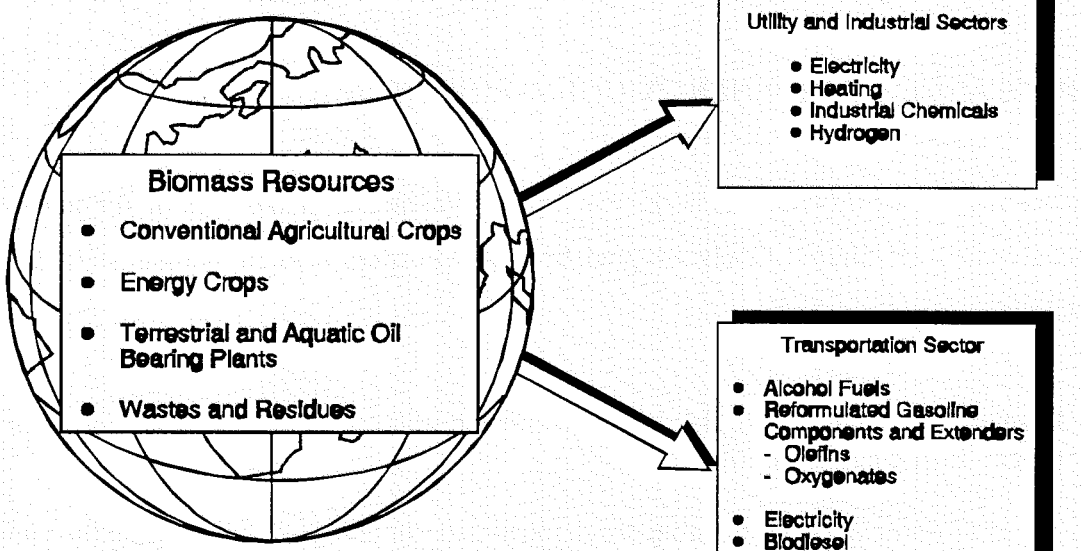
The enhancement of worldwide bioenergy use has the potential to make important contributions to the achievement of Shared Goals adopted by IEA Ministers at their 4 June 1993 meeting. These include:

- Diversity, efficiency and flexibility within the energy sector, as basic conditions for longer-term energy security
- The environmentally sustainable provision and use of energy, incorporating the view that renewable resources will have an increasingly important contribution to make
- Continued research, development and market deployment of new and improved energy technologies, through international collaboration which encourages industry participation and co-operation with IEA non-member countries.

Energy technology progress is critical to meeting IEA needs for energy security, environmental protection, and economic and social development. A fundamental restructuring of the global energy balance is in progress. The accelerating growth of energy use in developing countries leads to the increasing importance of their energy supply and demand decisions on all aspects of global energy and environmental impacts. The resulting needs for accelerated development and deployment of sustainable energy fuels and technologies increases the importance of IEA collaboration on bioenergy (along with other sustainable and renewable technology areas), because of the ability to meet a diversity of IEA Shared Goals through the successful advancement of this single technology area.

The diversity of sources and the breadth of potential uses for biomass energy is indicated in Figure 2 .

Figure 2
The Untapped Potential of Bioenergy



Biomass resource utilisation and bioenergy technology development can assist national and international energy diversity needs in many sectors of the economy.

While biomass provides well in excess of ten percent of the world's primary energy supply today, much of this use is non-commercial and of low efficiency. The modernisation of bioenergy technology and the full commercialisation of the bioenergy potential as an alternative to, and partial replacement of diminishing segments of today's conventional energy resources, will indeed expand the world's energy supply. It also will contribute significantly to the IEA members' ability to cope with potential instabilities in the world's oil markets. Bioenergy can be an important indigenous resource for many nations, can provide domestic jobs, and can displace imported oil, both directly (as a source of alternative liquid fuel) and indirectly (as a source of electricity for battery-powered vehicles). Furthermore, in doing so, its fundamental characteristic as a renewable energy resource provides the potential for effective integration of energy and environmental impacts, including major reduction in global greenhouse gas emissions. The capability for adoption as an energy technology of choice by both, IEA and developing nations, emphasises its global importance, as well as its value as an area for expanded collaborative co-operation and interaction with non-member countries.

The Rio Earth Summit, held in Brazil in 1992, emphasised the commitment of both developed and developing nations to sustainable, environmentally benign development. On a national basis, the needs for continuing social and economic development combine with energy security concerns and a recognition of the importance of caring for the natural as well as the human environment, to provide the incentives for the development of expanded access to new energy resources and improved technologies. Increasing support of bioenergy options in national programmes further indicates the growing importance of this area within the IEA programme of international collaboration.

While the potential benefits are clear to those knowledgeable of bioenergy, there are still many obstacles to be overcome in the development and deployment of these technologies, both of technical and non-technical origin, before large-scale deployment is realized. On the technical side, the obstacles are very technology-specific and are not addressed individually in this plan. It should be noted, however, that many technologies face common impediments, such as long-term reliable source of biomass feedstocks, efficient and cost effective harvesting or collection systems, suitable and economic conversion processes of high yield, and established markets or end-use for the fuel product. Waste management, emissions control, and other environmental

issues are of concern to most bioenergy technologies, and must be properly addressed to realize the desired environmental benefits.

The Bioenergy Agreement has played a successful role in coordination of work in national programmes concerned with assessment and research and development activities across the wide range of bioenergy technologies. So far, it has not focused to the same degree on the non-technical barriers that bioenergy, in common with other renewable energy technologies, will face as its technologies move into the deployment phase. These non-technical barriers include:

- Limited awareness of the technology among potential investors and users
- Steps to create a financial regime that encourages investment in the first projects in an area
- Development of confidence in the technology
- Development of a sufficient pool of skill and experience to implement the technology successfully
- Building up public acceptance of the technology, such that proposals do not fall foul of planning constraints or local resistance
- Creating a legislative framework that does not discriminate against the new technology and perhaps positively encourages its adoption.

These barriers to the uptake of bioenergy need to be addressed as the technologies mature and the many desirable incentives for their adoption lead to increased demand for the benefits they can provide. The above factors, which can increase market risk for industrial entrepreneurs and thereby constrain the rate of commercial investment and deployment, are now receiving additional attention within the national programmes of the members of the IEA Bioenergy Agreement. Accordingly, this becomes an important new area for expanded collaboration.

In the next section of this Strategic Plan, we consider those Objectives and Strategies that follow directly from the above presentation of potential benefits and significant barriers to timely adoption of bioenergy technologies and fuels.

IV. OBJECTIVES AND STRATEGIES

The Bioenergy Agreement aims to establish increased programme and project co-operation among participants. The programme to be carried out within the framework of the Bioenergy Agreement consists of co-operative research, development, demonstrations, joint work products, and exchange of information regarding bioenergy. This effort is designed to identify, facilitate and implement collaborative research to further the development and demonstration of bioenergy technologies of high priority to the national programmes. The overall objective of this effort is to assist participants in achieving the Vision and Mission of the Bioenergy Agreement. Collaborative work elements to accomplish this objective include the following activities:

- Gather, exchange, and evaluate information on bioenergy technologies of high potential, and the markets into which they may be deployed, including data on environmental issues, technological impediments, and cost competitiveness
- Encourage and facilitate collaborative research and development, while increasing the involvement of IEA non-member countries, leveraging research funds with industry participation, and overcoming barriers to the demonstration and market deployment of environmentally-favorable and cost-effective bioenergy technologies
- Promote joint work products, information exchange and technology transfer by international collaborative research, including systems studies, and by providing a forum for broad dissemination of results and innovative ideas for greater use and application of bioenergy fuels and technologies.

The proposed work programme for 1995-1997 supports important technology development and deployment needs towards a sustainable energy future. It strives for a combination of mutually reinforcing goals associated with achieving reduced environmental impact in open markets for energy systems; enhanced indigenous energy production and economic development; and an expanded flow of information on the research and development of renewable energy technologies. It seeks to advance these goals through a variety of Strategic Objectives (discussed below) which are embedded in the selection of task activities. The overall plan relies upon pre-established measures of success to monitor progress, and upon feedback from self-evaluations and public information dissemination to steer the task activity through time.

These generalised strategic concepts are shown in Figure 3. The specifics of the work programme are summarized in Table 1, and presented in greater detail as Appendix A to this Strategic Plan.

Figure 3
IEA Bioenergy Agreement Strategy: Turning Opportunity into Reality

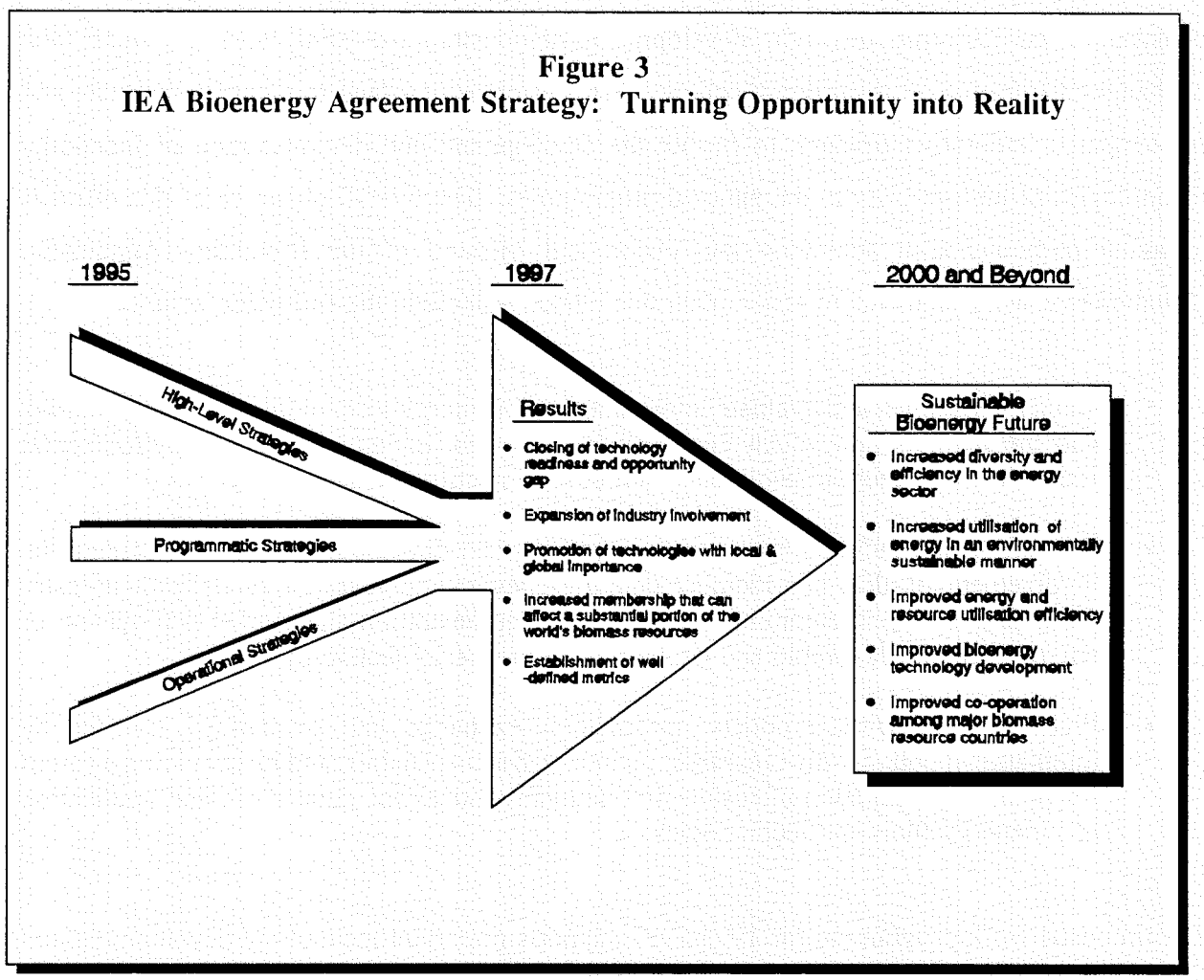


Table I
Summary of 1995 - 1997 Work Programme

Annex XII **Biomass Production, Harvesting and Supply**	• Conventional and Short Rotation Forestry • Agricultural Energy Crops and Residues • Interfacing and Systems Studies

- Increase available quantities of cost-effective biomass, and integrate production, harvesting, preparation, delivery, upgrading and conversion
- Enhance acceptability of liquid biofuels to modern engines and devices, compatibility with national environmental regulations, and energy and economic efficiency on a total systems basis
- Develop systems models to support the analyses of critical techno-economic factors, non-technical barriers and environmental impacts such as reduced greenhouse gas evolution

Annex XIII **Biomass Utilisation**	• Biomass Power and Heat Production • Production of Liquid Fuels and Related Products • Cross-cutting and Specialised Projects

- Support technical development, market entry and expanded deployment of biomass energy technologies for power and heat production based on combustion, gasification and anaerobic digestion
- Enhance production and utilisation of liquid biomass products for electric power, transportation fuels (such as gasoline, diesel fuel, and components of reformulated gasoline) and high-value specialty chemicals
- Perform techno-economic studies, environmental evaluations, and integrated fuel cycle analyses on an integrated systems basis to define biomass utilisation benefits and address barriers to expanded deployment

Annex XIV **Municipal Solid Waste (MSW)** **Conversion to Energy**	• Thermal Conversion of MSW and Refuse-Derived Fuel • Landfill Gas and Anaerobic Digestion • Integrated Waste Management

- Advance the development and deployment of energy recovery from MSW with emphasis on fuel quality, special waste streams, advanced conversion technologies, residue handling, emissions and environmental impacts
- Encourage the collection and efficient utilisation of landfill gas, and the increasing utilisation of anaerobic digestion of the organic fraction of MSW, with emphasis on integrated system design, mitigation of non-technical barriers and environmental system management strategies
- Enhance the development and use of integrated waste management systems and the modeling and decision analyses techniques needed for system characterisation and optimisation

High Level Strategies

High level strategies, which have been reflected in this work programme for responding to the promise of the Bioenergy Agreement Vision and the responsibilities of its Mission include:

- Maintain a broad and diverse program of activities reflecting a wide range of national interests, such that the needs and interests of individual participants, as well as those of the IEA as a whole, are met

- Seek to enhance the participation of industrial partners in Agreement activities, not only to increase the application of skills and knowledge to important ongoing activities, but also to ensure early integration of those market-oriented considerations that will be crucial to successful deployment of developed technologies

- Actively invite the involvement of IEA non-member countries in Agreement activities, within IEA-approved procedures for doing so, in those cases where interests in supporting the Bioenergy Agreement Vision and Mission coincide with those of current participants

- Develop active agendas with other interested international organisations (e.g., the World Energy Council) and organisations supporting international collaborative research and development (e.g., EUREKA) to multiply the effectiveness of the Bioenergy Agreement work products.

Programmatic Strategies

At the next level of the strategic hierarchy, the following programmatic strategies apply:

- Emphasise new collaborative activities, which address technical and non-technical barriers to deployment, both as an added input to the design of research and development activities and as an aid in the creation of a favorable national and global climate for the commercialisation of market-ready bioenergy fuels and technologies

- As adjuncts to the above strategy, seek appropriate opportunities to develop joint work products, pursue informative systems studies, and schedule significant one-time events. In addition, encourage broad dissemination to the public, the investment community, regulators, legislators and other non-technical stakeholders and decision makers of significant information on the technical, economic and environmental status, benefits and deployment opportunities for bioenergy applications

- Make expanded use of innovative and advanced communication techniques such as electronic mail and information exchange networks (e.g., Internet), and easily-accessible data bases (CD-ROM), as well as free distribution of information to specialised targets and multi-media presentations

- Integrate development, analysis and information exchange efforts on biomass production, harvesting and supply to achieve greater efficiency and impact of Task activities among these closely related elements

- Conduct Special Projects, to be implemented as a separate type of Task activity, with the intent of early initiation of one or more such projects.

With regard to the concept of Special Projects, it is envisioned that such an approach would accommodate those member countries which, with the backing of industrial partners, feel deployment and commercialization could be achieved in areas not in the core Tasks if efforts or risks are shared with another member country having the same goal. Special projects may be substantially different in character from typical on-going Task activities for a variety of reasons, such as the following:

- The project may have significant industrial input

- The project may have specialised intellectual property rights considerations

- The project may be of shorter-than-usual duration with a large budget

- The technology(ies) being commercialized or deployed may not be as advanced as those being pursued under the core Tasks.

As discrete activities, each Special Project would have its own Special Project Manager, responsible for all financial, legal and administrative aspects of the project. It is envisioned that selection of the Special Project Manager would be at the discretion of participating countries. The scope of work, project duration, evaluation of results, and similar matters would be clearly defined as for current Tasks. It is also envisioned that Special Project activities would have the full support of the IEA Office of Legal Counsel in developing the necessary contractual documentation.

Operational Strategies

Finally, some strategic elements are associated more with operational considerations than with programmatic aspects. Strategies of this character include the following:

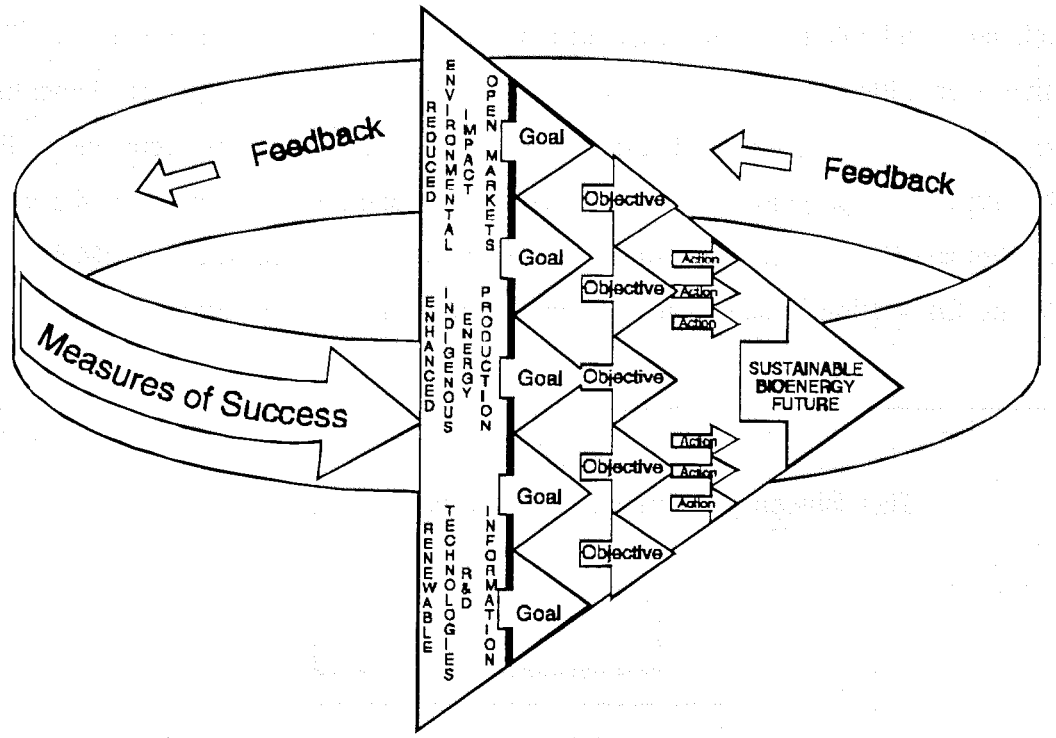
- Seeking out opportunities to support bioenergy initiatives of the parent IEA Renewable Energy Working Party and the Committee on Energy Research and Technology
- Seeking out opportunities for increased interaction with other IEA Implementing Agreements, Working Parties, Information Centres and activities, through such techniques as exchange of minutes, observers, joint workshops and conferences, and joint work products
- Increasing emphasis on Task milestones and metrics, peer review, and periodic evaluation procedures in accordance with ongoing guidance from higher level organisational units of the IEA (See Appendix B for a discussion and summary of current guidance).

These strategies are intended to be incorporated into the design and management of ongoing Tasks by their Operating Agents. Success in their implementation is one basis of evaluation by the Executive Committee. A visualisation of the contribution of the strategies to the success of the current work programme and a future sustainable bioenergy future is shown in Figure 4.

With respect to the post-1997 period, the current work programme foresees continued value to activities under the Bioenergy Agreement. To the extent feasible, current activities will build towards a future which will accomplish continuing advancements in:

- Closing the gap between technological readiness and market opportunities
- Expanding industry involvement through Special Projects and other activities with a near-term focus
- Growing utilisation of technologies for enhanced indigenous energy production
- Promoting technologies with important local and global environmental benefits

Figure 4
Strategic Roadmap to a Sustainable Bioenergy Future



- Increasing membership with emphasis on those countries with large biomass resources

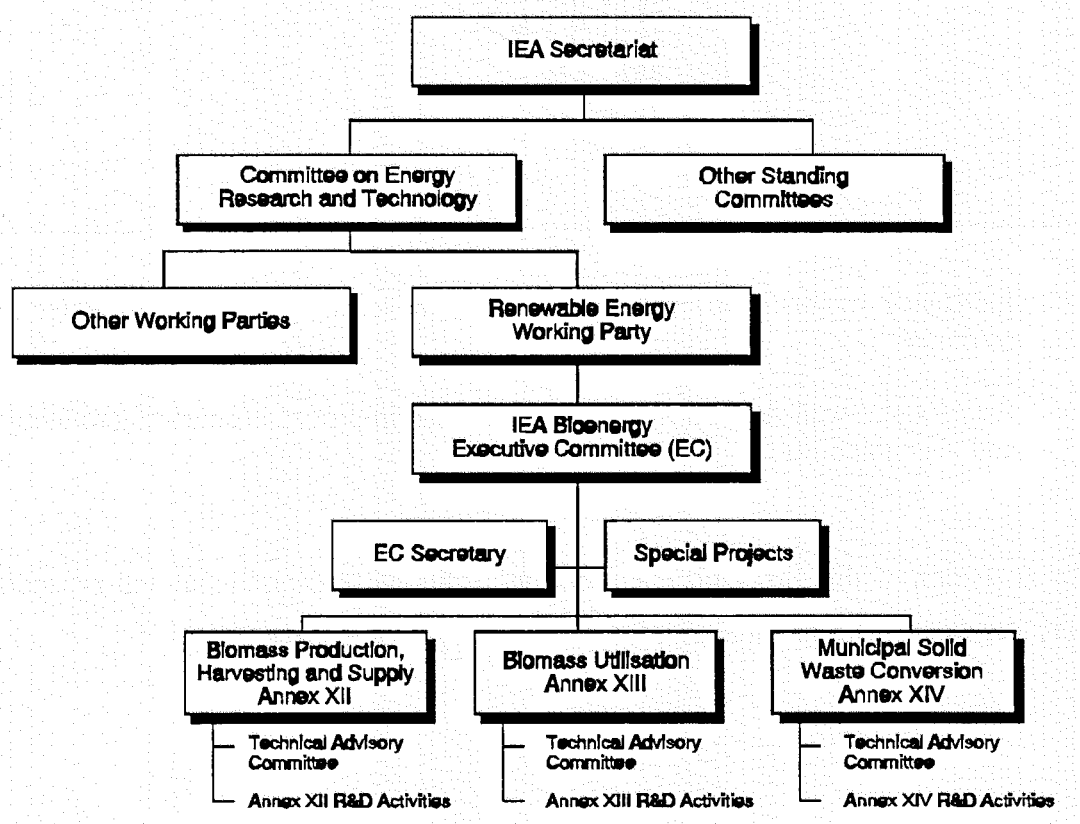
- Establishing well-defined metrics to encourage improved efficiency, productivity and accountability.

The next section of this Strategic Plan presents additional organisational and procedural aspects associated with the operation of the Bioenergy Agreement.

V. ORGANISATIONAL AND PROCEDURAL INFORMATION

The Bioenergy Agreement is administered by an Executive Committee reporting to the Renewable Energy Working Party which, in turn, reports to the IEA Committee on Energy Research and Technology. This organisational structure is shown in Figure 5. The Executive Committee manages the work activity under a Bioenergy Implementing Agreement, which has separate task areas delineated by Annexes to the Agreement. For the 1995-1997 work programme, three Annexes are operational. These cover the work areas of Biomass Production, Harvesting and Supply; Biomass Utilisation; and Municipal Solid Waste Conversion. Each such work area is managed by an Operating Agent, and

Figure 5
IEA Bioenergy Agreement Organisational Structure



is supported by a Technical Advisory Committee. In addition, provision is made in the organisational structure for one or more Special Projects to be included, also under the direction of the Executive Committee, whenever such projects are agreed to and implemented.

The Bioenergy Agreement is open to full participation by all Organisation for Economic Co-operation and Development (OECD) countries, and, by a special provision, to the European Union. As noted earlier, fifteen countries and the European Union are participating in 1994. Increased efforts are planned to involve other interested OECD countries not yet active in this programme, by issuing invitations to participate at workshops and meetings at Task level and in Executive Committee discussions.

There are also provisions for non-OECD countries and for international organisations to become Associate Contracting Parties. The possibilities for an effective co-operation are already under discussion with one candidate participant, and similar exploratory discussions with others will be conducted on a case-by-case basis. Because of the global importance of bioenergy in the world's future energy balance, such expanded involvement is expected to be mutually beneficial to an ever-widening group of nations.

Particular attention is also being given to the involvement of international funding organisations such as the World Bank, in connection with the commercial application of renewable, environmentally-friendly, energy technologies in developing countries.

Industrial sponsors are also welcomed to collaborate and interact in any of the technology areas. Since the IEA Bioenergy program will gradually contain more and more of market deployment, the involvement of industrial partners is expected to be of great importance. Indeed, experience in other technology areas has shown that the involvement of potential producers and users is highly desirable, even at very early stages of research and development, in order to introduce commercial insights into the research design, and thus to increase the likelihood of market success in addition to technical success.

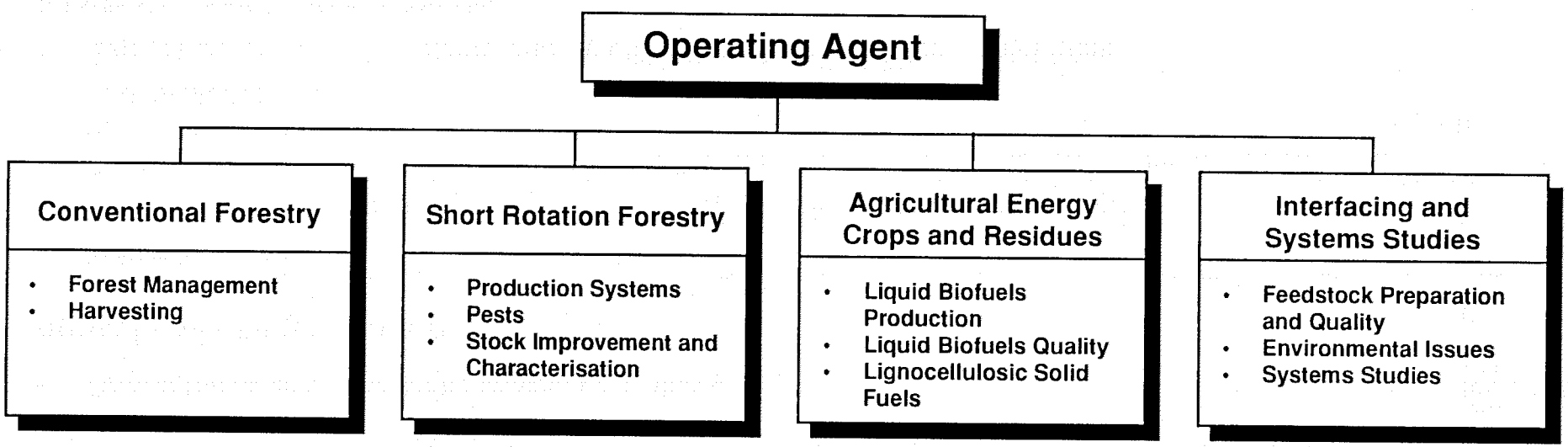
Written progress reports are presented twice each year by the Operating Agents for the approval of the Executive Committee. Short progress reports are also presented on an annual basis in the IEA Bioenergy Annual Reports. At the end of the Task period a Summary Report is presented by the Operating Agent in collaboration with the Activity Leaders. The Summary Reports are refereed and published through a scientific publisher. The Executive Committee encourages the publication of the Summary Report through a highly respected publisher and is providing separate funding to cover editorial costs and the cost for a bulk purchase of the report.

As world use of bioenergy technologies increase, the Bioenergy Executive Committee is committed to the enhanced relevance and significance of its work programme, not only to its participating Members, Associate Contracting Parties and Sponsors, but also to the work of the IEA as a whole. Priority will be given to productive interactions with other interested elements of the IEA and to the advancement of the IEA Shared Goals for a secure, sustainable and diverse global energy system.

APPENDIX A

PROPOSED 1995-1997
TASK ACTIVITIES

Task XII
Biomass Production, Harvesting and Supply



Conventional Forestry

- Increase available quantities of cost-effective forest biomass
- Develop silviculture strategies and forest management practices
- Integrate harvesting, preparation and storage, and delivery of wood fuel
- Understand factors influencing cost and efficiency to support supply strategies

Task XII
Biomass Production, Harvesting and Supply (cont'd)

Short Rotation Forestry

- Update production systems handbook and develop computerised version
- Investigate potential of additional species of woody crops
- Evaluate increased use of mechanisation, and improve means for disposal of sewage sludge and wastewater
- Monitor and characterise pathogens in order to develop environmentally and ecologically-safe pest control systems
- Characterise and genetically improve planting stock

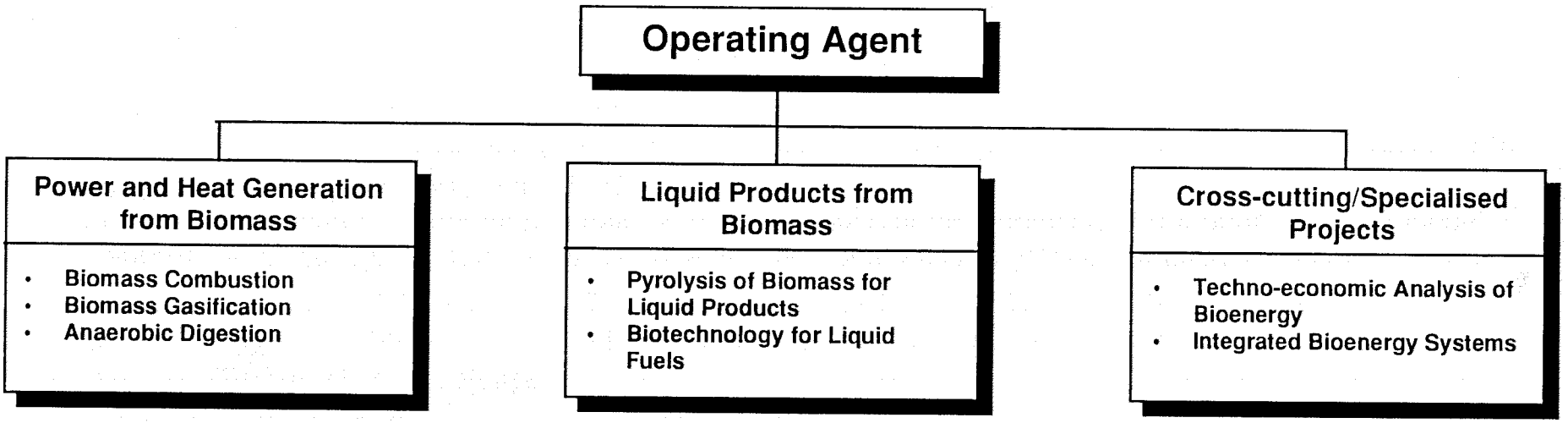
Agricultural Energy Crops and Residues

- Using a total systems approach, select and characterise new energy crops with improved agronomic and industrial potential
- Reduce costs of extraction and upgrading of liquid biofuels from energy crops
- Address requirements to increase acceptability of liquid biofuels to modern engines and devices, compatibility with national regulations on air quality and health, and energy and economic efficiency on a total systems basis
- Explore potential for increased energy utilisation of lignocellulosic solid fuels

Interfacing and Systems Studies

- Evaluate environmental consequences of intensive biomass systems, and develop guidelines to ensure their environmental soundness
- Develop systems models of bioenergy supply and use to analyse critical factors in the supply chain, conduct techno-economic assessments, investigate means to mitigate non-technical barriers, and evaluate the impact of bioenergy on greenhouse gas evolution

Task XIII
Biomass Utilisation



Power and Heat Generation from Biomass

- Develop improved efficiency and environmental acceptability of both small- and large-scale biomass combustion, including diverse feedstocks and co-combustion methodologies
- Improve biomass gasifiers and promote their commercialisation
- Examine barriers/constraints to economic biogas production, and explore solutions for overcoming these restrictions

Task XIII
Biomass Utilisation (cont'd)

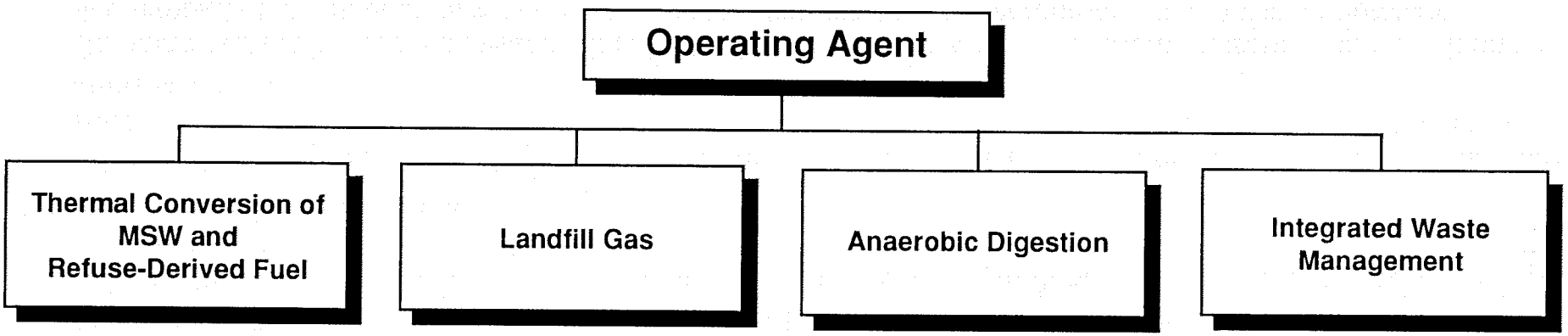
Liquid Products from Biomass

- Advance the technology for production of liquid fuels and high value chemicals through biomass pyrolysis and liquefaction
- Advance the technology for production of liquid fuels and high value chemicals through biomass fermentation and conversion
- Model key conversion processes and relate performance of operating facilities to technical and economic analyses of totally integrated bioconversion processes

Cross-cutting/Specialised Projects

- Perform techno-economic analyses of integrated gasification/combined cycle systems, power production with pyrolysis technology, liquid transportation fuels, and similar advanced bioenergy systems
- Perform fuel cycle total systems analyses of integrated biomass production/harvesting, conversion and utilisation, including consideration of key aspects such as nutrient depletion, greenhouse gas balances, solids recycle, and trace element management
- Characterise waste streams and define options for treatment/remedial action for effective management of biomass system environmental impacts

Task XIV
Municipal Solid Waste (MSW) Conversion to Energy



Thermal Conversion of MSW and Refuse-Derived Fuel

- Evaluate key aspects of MSW and Refuse-Derived Fuel (RDF) conversion to energy, including fuel quality, plant experience, energy recovery from special waste streams, advanced conversion technologies, residue (including ash) handling and disposal, emissions and environmental impacts
- In the area of advanced conversion technologies, co-ordinate gasification interests with related activities under Task XIII, and identify areas where significant differences may exist between gasification of biomass and of MSW
- In the area of special waste streams, emphasise investigations of waste wood, tyres, and plastics, linking with work on gasification technology where appropriate
- Improve understanding of co-combustion processes, such as MSW with coal, peat , and sludge, including a focus on emission standards and flyash composition; improve understanding of combined heat and power configurations and performance

Task XIV
Municipal Solid Waste (MSW) Conversion to Energy (cont'd)

Landfill Gas

- Aid in accelerating the deployment and use of landfill gas in participating countries, with an emphasis on the achievement of associated environmental benefits in waste management and in reducing the global contribution of landfill methane to the greenhouse effect
- Improve and promote efficient utilisation of landfill gas, including emphasis on economics, landfill design and management, and non-technical barriers to landfill gas exploitation
- Highlight research and development needs related to demonstration schemes, gas predictions and fuel cells utilisation

Anaerobic Digestion

- Stimulate continuing deployment of technologies for the anaerobic digestion of the organic fraction of MSW, with emphasis on plant design and experience, waste management strategies, composting, compost quality, and industrial support

Integrated Waste Management

- Advanced an integrated view of systems for energy recovery from wastes, with emphasis on identification of suitable wastes, a waste sorting model, environmental considerations, non-technical barriers, and decision analysis techniques
- Combine skills in life cycle analyses with practical knowledge of waste management issues, so as to identify and evaulate the influence of waste management systems on the environment, and assist in pursuing opportunities for waste volume reduction
- Concentrate on strategic (policy and planning) aspects, and on practical tools for decision-makers in order to support accelerated and expanded adoption of technologies ready for near-term application

APPENDIX B

REVIEW AND EVALUATION PROCESS

Appendix B
Review and Evaluation Process

Peer review and evaluation of programme activities are critical to achieving programmatic objectives. The value of scientific critique is self evident. It enhances technology acceptance by those developers and investors who would otherwise be reluctant to invest in technologies which are not clearly understood. It expands communication networks with other researchers and provides a potential source of meaningful alternatives to technological barriers through intellectual debate.

Currently the Bioenergy Agreement programme is reviewed twice each year with regard to relevance when progress reports from each Task are presented to the Executive Committee for approval. Brief progress reports are also included in the IEA Bioenergy Annual Report. A summary report is prepared by the Activity Leaders at the end of the Task and is published in refereed journals. Scientific merit is evaluated in this manner. The Executive Committee and IEA Headquarters review the Tasks upon conclusion.

After a careful examination of all the reviews which are conducted throughout the life cycle of a given Task, it is evident that adequate review and feedback mechanisms exist. This review process, conducted at the appropriate stages, ensures that both technical and financial integrity is maintained.

In an effort to quantify and standardise the evaluation process, Operating Agents have been directed by the Executive Committee to include the following in all new proposed plans of work:

- Planned milestones that are quantifiable and give a measure of progress and/or accomplishment
- Planned achievements that can be highlighted at the completion of efforts, and expressed in a form that can lead to corrective action early on, if required.

Included in the guidance to Operating Agents, the table below summarises suggested achievements that are considered by the Executive Committee to have significance and be

worthy of acknowledgement. This table is not exhaustive but establishes a suggested baseline.

Information Exchange	Direct R&D Cost Savings	Other Development/Implementation Benefits
Direct information exchange via workshops, etc. Establishment of a scientific/ technical/commercial network Production of research reviews, databases, etc.	Task sharing/co-ordination Definitions of protocols/standards Guides/manuals Techno-economic/ environmental assessments	Industrial spin-offs Collaborative spin-offs Technology import/export Policy inputs

The work in the Agreement to-date has been reviewed and evaluated by the member countries. It would be possible to extend and expand this evaluation procedure by building in additional review stages - further peer review by researchers, by industry, etc. However, it is judged that the benefits of such additional processes would be marginal, and not out-weigh the additional costs and complexity that such measures would involve.

With respect to internal review procedures, the Operating Agents can assist by concentrating the reports on the extent to which objectives have been met, and on the achievements of the Task, rather than merely reporting on the activities that they have managed, particularly at the end of the Task.

The recommended evaluation procedure is as follows:

- At the end of a Task, Operating Agents will receive reports from each area of activity which spell out the achievements of that area
- These individual area reports, along with the technical outputs from the Task will be reviewed by the Technical Advisory Committee
- The Operating Agent will compose an Overview which draws together the main conclusions and achievements in the Task as a whole. This overview will also highlight

any lessons - technical, organisational, managerial, or financial - that could affect future work in the Agreement

- These reports will be reviewed by the Executive Committee
- The Chair will note the views of the Executive Committee in a brief covering note. This, together with the Operating Agent's reports, will form the evaluation report which will be made available to the Renewable Energy Working Party as well as the Executive Committee members.

The Executive Committee is also encouraging that the results of the work within the Agreement be published in well-respected journals, books or report series.

In most cases, workshop reports, etc., are being issued as institute reports or similar documents which can be published rather quickly. However, participating scientists may desire to have the results published through more prestigious, refereed channels. This may take some additional time, but the Activity Leader should, in consultation with the Operating Agent, consider which publication or combination of publications are to be preferred in each case, from the participating scientists as well as from the IEA Bioenergy point of view, for publication in these more prestigious journals.

IEA Bioenergy Agreement Directory

Interested parties are encouraged to contact appropriate individuals below to explore interest in participating in collaborative activities or to seek additional information on programme activities.

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